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Full Length Research Paper

Structural breaks, electricity consumption and economic growth: Evidence from Ghana

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This study examines the causal relationship between electricity consumption and economic growth for Ghana during the period 1970 to 2010. The study employed unit root and cointegration tests taking into account structural breaks. The following findings were made: First, a plot of the series indicated a trend pattern. The series also experienced structural breaks in 1979 and 1983 but after taking structural breaks into account they became stationary. Second, the series exhibited one cointegration vector implying a long–run relationship between them. Third, the results revealed the presence of unidirectional Granger causality running from economic growth to electricity consumption. In general, the study identified the presence of structural break dates which corresponded with the critical economic events in Ghana.

Key words: Electricity consumption, economic growth, structural break, vector error correction mode (VECM), causality.

INTRODUCTION

Economic growth requires the utilization of energy to generate tangible and intangible technological advancement and productivity growth (Chang and Hu, 2010). The augmented neoclassical growth theory suggests that energy utilization of an economy has an implicit positive linkage with economic growth. This linkage is argued on the grounds that energy can be drawn on as an input substitute or complementary to other factors of production and also serve as the interface between technological advancement and productivity using production function and the general equilibrium approaches (Zachariadis, 2007).

On the other hand, electricity consumption may be induced by economic growth in many ways: First, at the end-use economic growth generates income to consumers which enable them purchase electrical appliances which relates directly to electricity usage. Second, economic growth promotes business participation in economic activities which induces the usage of electricity (Islam et al., 2011).

Even though, this linkage indicates no causality between energy consumption and economic growth in any direction, causality between them will substantially aid in fashioning energy and growth policies for Ghana's economy to maintain the middle-income status chalked recently.

The direction of causal relationship between economic growth and electricity consumption has generated a fierce debate among economists in the world over and no accord on the issue of whether economic growth is the cause or affects energy usage has yet been made (Narayan and Smyth, 2005).

The presence of Granger causal relationship from economic growth to electricity consumption or the absence of it in whichever direction means that plans for electricity consumption will have no adverse effect on economic growth. However, if there is Granger causality from electricity usage to economic growth the consequence is that electricity preservation policies would affect economic growth since a shortage in electricity usage will result in a decrease in economic growth (Jumbe, 2004).

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However, economic growth and electricity consumption may be affected by structural breaks such as exogenous factors and regime changes in the course of development (Lee and Chang, 2005). As a result the relationship between economic growth and electricity consumption may experience extreme variations as modification of energy policy, reforms in the energy demand and supply sectors as well as institutional changes occur in the economy. Within the period 1970 to 2010, the economy of Ghana experienced a number of economic restructuring, including the launching of "Operation Feed Yourself" a policy which emphasized principally on achieving food self-sufficiency in 1972 and adoption of economic recovery programme in 1983 as a mean of reversing the decaying trend of economic activities (Killick, 2010) and the adoption of highly indebted poor country (HIPC) initiative in 2001. On the negative side the economy of Ghana was affected by the 1970s oil crises which did not only induce an astronomically rise in the international cost of raw materials but created an imbalance between supply and demand for oil. Finally, the hydroelectric power plants at Akosombo and Kpong which for a long time have been the main source of power generation in the country were plagued by seasonal variations in water levels that created periods of severe electricity crises in 1983, 1993, 1998 to 1999 and 2006 to 2007 respectively.

Conducting structural breaks test is very important because of the association between electricity market and the economic system. The exogenous shocks and regime change caused the economy of Ghana to sink into a recession 1983 during which negative growth rate of gross domestic product were recorded. This compelled government to implement energy conservation measures by closing down some part of Volta Aluminum Company (VALCO) in 1983 and introduced six million pieces of energy saving bulbs in 2008 to 2009. These measures altered the pattern of electricity usage by most Ghanaians since the variations in electricity usage may be a contributory factor to structural breaks in the electricity-growth nexus. As a result, structural breaks brought by the presence of variations in electricity usage need to be taken into consideration when modeling the electricity-growth nexus for policy makers.

The variations in the economic system may induce a permanent effect on the parameters of the model which will generate spurious results when employed for forecasting (Glynn el al., 2007). Unlike past studies, our study modeled the electricity-growth nexus and make conclusion by incorporating possible structural breaks into the equation. However, to incorporate structural breaks into the model the following issues should be taken into consideration. First, in examining the electricity-growth nexus the vector autoregressive (VAR) procedure to causality may leave out the vital long-run information that may be present in the model. The VAR procedure may also produce spurious results in the presence of cointegration between the variables (Lee and Chang, 2005). Second, the presence of structural breaks in the series can bias the tested statistical results in the direction of non-rejection of the null hypothesis of unit root (Perron, 1989). Perron contended that a good number of macroeconomic series are not distinguished by a unit root instead that persistence macroeconomic fluctuations are as a result of very large and irregular shocks and the economy may only reverse to deterministic trend in the presence of small and regular shocks. Third, neglecting the structural break problem may render the results incapable of examining the stability or otherwise of the parameter estimates within each sub-period. A bias in the parameter estimates may cause an acceptance of unit root hypothesis in the presence of stationarity of the series.

There are three objectives for this study. First, this study seeks to test Ghana's data for the past 41 years, during which the economy experienced a lot of economic restructuring as well as policy modifications. These activities may induce structural changes in the data of economic growth or electricity consumption which can affect the result of the stationarity test. Second, we examine the cointegration relationship between electricity usage and economic growth by employing Johansen's (1988) procedure. Finally, following the cointegration results the study employs the vector error correction (VEC) model to undertake causality test between economic growth and electricity consumption and performs structural break test using Gregory-Hansen (1996) test procedure.

In Ghana there are no studies examining the electricity-economic growth nexus with structural breaks. This study fills this gap by conducting the electricity-economic growth nexus by employing Zivot and Perron procedures to test the existence of structural breaks with special reference to Ghana. This study is relatively different from the recent study by Adom (2011) who observed the causality between electricity usage and economic growth for Ghana. The author conducted the causal relationship using a bivariate approach with the Toda-Yamamoto framework. Even though this study also conducted Granger causality in a bivariate approach, it used a Johansen's (1988) to cointegration and the VECM causality approaches.

The rest of this study is structured as follows. The second section sets the review of the relevant literature. The third section outlines the methodology and data description. The results are shown and discussed in section five; section six presents the conclusions and policy implications.

LITERATURE REVIEW

The influential paper presented by Kraft and Kraft (1978), generated extensive works on the relationship between energy utilization and economic growth. Nonetheless, the results of these research works produced inconclusive findings. Following the inconclusiveness characteristic of these findings we group all past literature into two; namely, the bivariate and multivariate approaches. The bivariate approaches include: Soytas et al. (2003) who examined the causality between economic growth and energy utilization with Johnsen-Juselius cointegration and vector error correction approaches for Turkey covering the period 1960 to 1995. Their findings revealed a unidirectional Granger causal relationship which runs from energy utilization to economic growth. This implies that policies initiated towards growth must be tailored to considerable accelerate the improvement of the energy sector in term of technology efficiency and cost-effectiveness to hasten economic growth.

Altinay and Karagol (2005) examined the causality between electricity utilization and real GDP spanning the time frame 1950 to 2000 for Turkey. They employed the Dolado-Lutkepohl and the standard Granger causality test and detrended the data. Both assessments reported highly significant unidirectional causal relationship which runs from electricity utilization to economic growth. Their findings indicated electricity as a key determinant of economic growth and therefore, effort should be made to sustain its production in Turkey.

Lee and Chang (2005) investigated into the causality between economic growth and energy consumption with structural breaks for Taiwan from 1954 to 2003. Disaggregating energy into coal, oil, gas and electricity they found that gas consumption had experienced structural breaks in the 1960s. The results also revealed the presence of causality in different directions between economic growth and the various energy sources. Finally, they found that the long-run relationship economic growth and energy consumption was unsteady and they concluded this situation may have been caused by some macroeconomic activities.

Ciarreta and Zaraga (2005) examined the linear and nonlinear causality between electricity utilization and economic growth for Spain covering the time frame 1971 to 2005 employing the Toda-Yamamoto and Dolado-Lukepohl procedures. Their findings revealed that the series were stationary after first differencing and indicated the presence of a unidirectional linear Granger causal relationship which runs from economic growth to electricity utilization. However, nonlinear approach indicated no proof of Granger causal relationship between economic growth and electricity utilization. Ho and Siu (2006) used the novel dataset on electricity consumption and reported four main findings: (1) the presence of cointegration relationship between economic growth and electricity utilization; (2) a unidircectional Granger causal relationship which runs from electricity utilization to economic growth; (3) a highly significant speed of adjustment whenever disequilibrium occurs; (4) existence of structural variations in the connection between electricity utilization and economic growth.

Chontanawat et al. (2006) examined causal relationship between electricity and economic growth employing a reliable data set for 30 OECD and 78 non-OECD countries. Their study yielded bidirectional causality between energy utilization and economic growth for most of the developed Organization for Economic Cooperation and Development (OECD) economies in contrast to the emerging non-OECD economies. As a result any environmental policy aimed at reducing pollution brought by electricity production will have stronger significant effects on the developed OECD countries than the developing ones.

Erbaykal (2008) using disaggregated energy (oil and electricity) utilization and economic growth covering the time frame 1970 to 2003 for Turkey. His study employed the ARDL bound procedure to cointegration proposed by Pesaran et al. (2001).

The results indicated that both oil and electricity consumption had statistically significant positive relationship with economic growth in the short run. However, in the long run oil consumption maintained a positive significant relationship with economic growth whiles electricity indicated a significant inverse relationship with economic growth.

Qazi and Riaz (2008) for Pakistan applying annual data from 1971 to 2007 and the autoregressive distributed lag bound test procedure to cointegration reported mixed results. In the short run, they found a bidirectional causal relationship between energy utilization and economic growth. In the long run however, they reported a unidirectional causal relationship which runs from economic growth to energy utilization. The absence of causal relationship between energy utilization and economic growth implies that soaring cost of energy depresses investment leading to unproductive effect on economic growth.

Kebede et al. (2010) using cross-sectional time series data for 20 countries in Africa spanning 25 years found positive and significant unidirectional evidence running form electricity utilization to economic growth for the majority of these economies. The implication is that these countries must vary their energy sources and launch energy-efficient devices and equipment to enable accelerates the pace of their economic development.

Abbasian et al. (2010) applied the vector autoregressive (VAR) techniques of Granger Toda-Yamamoto approaches and found out economic growth Granger causes energy utilization as well as petroleum products. The study covered the period 1967 to 2005 and revealed Granger causality running from economic growth to aggregate energy utilization as well as petroleum products. Their findings however, indicated no causal connection between other energy types and economic growth.

Adom (2011) employing yearly time series data spanning 1971 to 2008 and the Toda- Yamamoto procedure to cointegration conducted the causal relationship between electricity utilization and economic growth for Ghana. His findings uncovered the existence of a unidirectional causal relationship running from economic growth to electricity utilization. This implies adherence to energy conventions such the Kyoto Protocol will not adversely affect economic growth in Ghana.

The multivariate approaches are: Asafu-Adjaye (2000) using a multivariate approach, examined the causality between energy utilization, energy prices and economic growth for India, Indonesia, Philippines and Thailand employing cointegration and error correction procedures. The finding revealed a unidirectional Granger causal relationship which runs from energy to economic growth for India and Indonesia, whiles bidirectional causal relationship between energy and economic growth for Thailand and Philippines. Economic growth energy and energy prices were mutual causal for Thailand and the Philippines.

Narayan and Smyth (2005) in a multivariate study involving yearly data covering the period 1966 to 1999 using electricity utilization, employment and real income reported cointegration among these variables for Australia. Their study found a long-run causality between employment and real income on one hand and electricity consumption on the other hand. However, the short-run relationship indicated a fragile unidirectional Granger causality with the direction from real income to electricity utilization and employment.

Tang and Shahbaz (2011) scrutinized and re-investigated the cointegration and the causal relationship between electricity utilization, income, financial development, population and foreign trade in Portugal with the autoregressive distributed lag bound procedure to cointegration. With data spanning 1971 to 2009 their study revealed the existence of cointegration among the variables and reported a bi-directional causal relationship between electricity utilization, real income, and population on one hand and a unidirectional causal relationship which runs from financial development to electricity utilization. These results indicate Portugal as energy-reliant economy and therefore energy conservation policies are vital for high economic growth.

Bekhet and Othman (2011) undertook the causality relationship between electricity consumption consumer price index (CPI), gross domestic product (GDP) and foreign direct investment (FDI) in Malaysia. They employed time series data spanning 1971 to 2009 and estimated the causal connection between these variables using the vector error correction model (VECM). Their findings reported long-run relationship among the variables and indicated a significant long-run causality which runs from electricity utilization to FDI, GDP and CPI respectively. These findings imply that electricity is a key variable for growth and as a result policy should be geared towards improving its production and sustainability. Table 1, summaries the author, approach, econometric methods and results most of the studies cited in the literature review.

METHODOLOGY

This part describes the methodology and data sources employed by this study. The methodology is categorized into three procedures.

Unit root test with structural breaks

Time series data experience unit root or non-stationarity when the means and variance vary over time. Originally the presence of unit root in a series were tested by the augmented Dickey-Fuller (1979, ADF), Philips and Perron (1988, PP), and Elliot et al. (1996, DF-GLS) procedures. However, these test procedures may cause the non-rejection of the null hypothesis of unit root when structural events which may induce shifts in regime are incorporated in the model (Lee and Chang, 2005). To overcome this difficulty Zivot and Andrews (1992, ZA) and Perron (1997) suggested robust procedures for incorporating endogenous structural breaks in the model.

The ZA (1992) and Perron (1997) procedures suggested two hypotheses of testing for unit root with structural breaks; the null hypothesis that support the presence of unit root against the alternative of a broken trend stationary process. However, the ZA procedure uses the complete sample and a different variable for each probable break date. In this case the selected break date corresponds to the value where the t-statistic is most negative (Glynn et al., 2007). The Perron test on the other hand chooses the break date at the point where the change in the slope on the break term is maximized (Lee and Chang, 2005).

The test for unit root hypothesis with structural breaks in the electricity-growth nexus has at least two merits. First, it thwarts a test outcome which may be biased in the direction of non-rejection of the null hypothesis. Second, its capability of recognizing the probable existence of structural breaks in the model offers vital information for examining whether a structural break on certain series are attributed to peculiar government policy, economic crisis and regime change (Glynn, 2007).

Cointegration

The second procedure is to examine the presence of cointegration relationship between electricity consumption (EC) and economic growth (Y). The presence of cointegration is very important since it proofs the reality of long-run equilibrium connection between economic growth and electricity consumption. A long-run equilibrium relationship between the variables is an indication that these variables move collectively over time so that short term shocks from the long term development will be corrected. The absence of cointegration between these variables implies no long-run equilibrium relationship and as a result these variables will drift randomly from themselves. The presence of the long-run equilibrium relationship between the variables indicates that linear combinations in no-stationary series have become stationary (Engle and Granger, 1987). To test for the existence of cointegration between the series the study used the Vector Autoregressive (VAR) procedure suggested by Johansen (1988). Johansen (1988) proposed a p-dimensional VAR of the order $k[VAR(k)]$ which may be modeled as:

$$Z_t = d + \Pi_1 Z_{t-1} + ... + \Pi_k Z_{t-k} + \omega_t (t = 1...T) \qquad (1)$$

Alternatively the first difference form of equation (1) may be written as:

Table 1. Summary of the literature review.

Author	Approach	Econometric methodology	Results
Asafu-Adjaye (2000)	Multivariate	Vector error correction model	Unidirectional Granger causal relationship runs from energy to economic growth for India and Indonesia, whiles bidirectional causality between energy and economic growth for Thailand and Philippines
Narayan and Smyth (2003)	Multivariate	ARDL, Johanse-Juselius and vector error correction model	Unidirectional Granger causality with the direction from real income to electricity consumption and employment
Soytas et al. (2003)	Bivariate	Johan-Juselius	A unidircectional Granger causality running from electricity consumption to economic growth
Altinay and Karagol (2005)	Bivariate	Delado-Lutkepohl	A unidircectional Granger causality running from electricity consumption to economic growth
Lee and Chang (2005)	Bivariate	Panel analysis	A unidirectional relationship for most of the countries in the short run and a bidirectional relationship in the long run in the case of the panel data set for most of the countries
Ciarreta and Zaraga (2005)	Bivariate	Toda-Yamamoto and Delado-Lutkepohl	A unidirectional linear Granger causal relationship which runs from economic growth to electricity utilization
Erbaykal (2008)	Bivariate	ARDL	A unidirectional relationship from electricity consumption to economic growth
Qazi and Riaz (2008)	Bivariate	ARDL	A bidirectional causal relationship between energy consumption and economic growth in the short run and a long run unidirectional causality running from economic growth to energy consumption
Abbasian et al. (2010)	Bivariate	Vector autoregressive	Economic growth Granger causes aggregate energy consumption as well as petroleum products
Adom (2011)	Bivariate	ARDL, Toda-Yamamoto	Unidirectional causality running from economic growth to electricity consumption
Tang and Shabbaz (2011)	Multivariate	ARDL	A bi-directional causality relationship between electricity consumption, real income, and population on one hand and a unidirectional causality running from financial development to electricity consumption
Bekhet and Othman (2011)	Multivariate	Vector error correction model	Unidirectional relationship running from electricity consumption to FDI, GDP and CPI

$$\Delta Z_t = d + \Pi_k Z_{t-k} + \sum_{t=1}^{k-1} \theta_i \Delta Z_{t-i} + \omega_i \quad (2)$$

where Δ denotes the first difference operator, Z_t is a 2×1 vector comprising [log (economic growth), log (electricity consumption)]; d represents the 2×1 vector of the intercept, θ_i and Π are the 2×2 matrices of the coefficients and ω_t is 2×1 matrix of the error term. The matrix Π assumes all information of the long-run relationship between economic growth and electricity consumption. A full column rank of the matrix Π is an indication of stationarity between the variables in Z and a zero column matrix rank of the Π suggests a first-difference of the VAR in which all long run information are missing. However, if the rank of matrix falls within the intermediate range ($0 \prec rank(\Pi) = r \prec p$) it will produce an r cointegrating vector capable of generating stationarity in the linear combination of Z (Narayan and Smyth, 2005). This implies examining cointegration relationship between the variables entails testing for the rank of Π matrix. This is accomplished by testing whether the eigenvalues of Π are considerably diverse from zero. The study used two techniques -the trace test and the maximum eigenvalue test- to examine the number of cointegrating vector in the vector error correction (VEC) model. The study specifies the likelihood statistic for examining the trace test as:

$$LR_{trace}(r/k) = -T\sum_{i=r+1}^{k} ln(1 - \dot{\gamma}_i) \quad .(3)$$

where $\dot{\gamma}_i$ denotes approximated $2-r$ least eigenvalues and $r=0$ and 1. The null hypothesis states that there are most r cointegrating vectors against the alternative of r is bigger compare to 0 or 1. The maximum eigenvalue statistic test is represented as:

$$LR_{\max}(r|r+1) = -Tln(1 - \gamma_{r+1}) \quad (4)$$

The null hypothesis represented by r cointegration vector is tested against the alternative of $r+1$. This can be summarized as follows: the null of $r=0$ is tested against the alternative of $r=1$ and the null hypothesis of $r=1$ is also tested against the alternative of $r=2$. The choice of lag length was made by using the Akaike information criteria (AIC).

Granger causality

The third step entails conducting the Granger causality test when the variables are cointegrated. According to Kirchgassner and Wolters (2007) suppose I_t denotes information set at time t, x and y denote the time series, $\bar{x}_t$ denotes all current and lagged of x, and $\sigma^2(\cdot)$ denotes the variance of the resultant forecast error, Granger suggested three main definitions of causality between x and y. First, x Granger causes y if and if the use of an optimal linear forecasting model results in $\sigma^2(y_{t+1}|I_t) < \sigma^2(y_{t+1}|I_t - \bar{x}_t)$ if future values of y forecasted can be enhanced when the current and lagged values of x are applied. Second, x instantaneously Granger causes y if and only if the use of an optimal linear forecasting model results in $\sigma^2(y_{t+1}|\{I_t, x_{t+1}\}) < \sigma^2(y_{t+1}|I_t)$, if y_{t+1} forecast can be enhanced when x_{t+1} including its current and past values are applied to y_{t+1}. Finally, there is feedback or response between x and y if x Granger causes y, and y Granger causes x.

However, Engle and Granger (1987) warned that if the variables are stationary after first differencing in the existence of cointegration the application of VAR to the analysis will be spurious. The outcome of the stationarity test using ADF and KPSS revealed that our variables are I (1). This is reported in Table 1. Since VAR is incapable of performing causality test at this point we adopted a procedure to causality known as the vector error correction model (VECM). This procedure does not only provide the short run dynamics but also the long run relationship between the variables through the use of the significant error correction term. The Granger causality test may therefore be examined by the VECM representation of multivariate $pth-$ order as:

$$\Delta lnY_t = \alpha_0 + \sum_{i=1}^{p}\alpha_{1i}\Delta lnY_{t-1} + \sum_{i=1}^{p}\alpha_{2i}\Delta lnEC_{t-1} + \varphi_1 ECT_{t-1} + \mu_{it} \quad (5)$$

$$\Delta lnEC_t = \beta_0 + \sum_{i=1}^{p}\beta_{1i}\Delta lnEC_{t-1} + \sum_{i=1}^{p}\beta_{2i}\Delta lnY_{t-1} + \varphi_2 ECT_{t-1} + \mu_{it} \quad (6)$$

where Δ denotes the first difference, the α_s, β_s represent the coefficients of the parameters to be estimated and ECT_{t-1} and μ_{it} represent the error correction term and the disturbance term. Equation 5 examines the causality running from electricity consumption to economic growth while Equation 6 tests the causality running from economic growth to electricity consumption. This procedure enables the study to differentiate the short run from the long run. The Wald χ^2 statistic from Equations 5 and 6 explains the short run causality between economic growth and electricity consumption whiles the $t-$ statistics provided by the lagged error correction terms explain the intensity of the long run causality effect. Granger causality in Equations 5 and 6 can be conducted in three ways: First, short run Granger causalities are determined by employing the F-statistic or the Wald statistic for the significance of the α_s and β_s coefficients of the $I(1)$ series. Asafu-Adjaye (2000) deduces short run causality as the weak Granger causality because the dependent variable acts in response to only short term disturbance to the stochastic term. Again, Masih and Masih (1996) cited the ECT in Equations 5 and 6 as another source of causality between the series. They indicated that the coefficients of the ECT's denote the speed that deviations from the long run equilibrium are removed due to variations in each variable. The t-test or Wald test for the significance of φ coefficients of the ECT_{t-1} are employed to test the long run causalities. Finally, Asafu-Adjaye (2000) stressed that the joint of the sources of the causal relation shows which series allows for the short run variation to restore long run equilibrium, due to shock in the system. This is referred to as the strong Granger causality tests.

Data sources and description

The paper used yearly time series data spanning 1970 to 2010. All

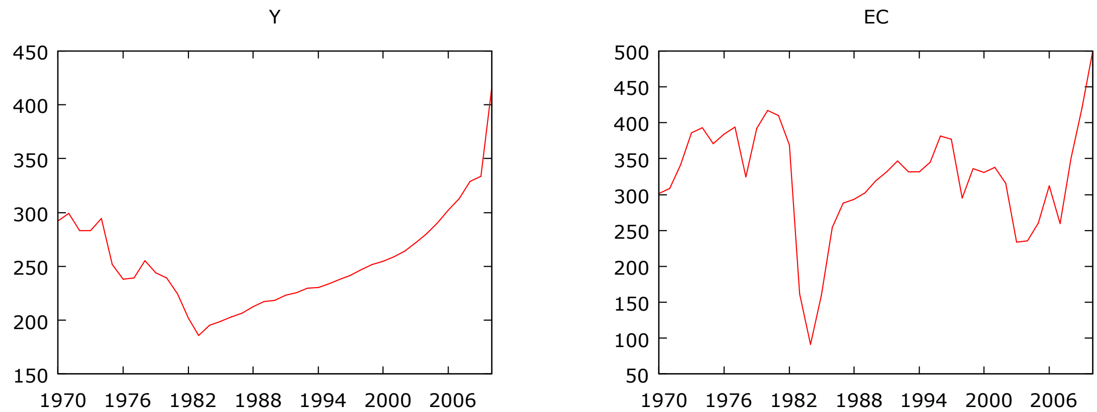

Figure 1. A plot of economic growth and electricity consumption.

the data were provided by the World Bank cd-rom 2010. The total electricity consumed was measured in kwh per capita. Economic growth was measured in real per capita income.

EMPIRICAL RESULTS

This part discusses the results of the unit root test, the cointegration test using the Johansen (1988) and the Granger causality test using the VECM.

Results of the unit root tests

A plot of the data of the series in Figure 1 show they are not stationary at the level but exhibit a trend pattern. Therefore the resultant unit root regressions were conducted with a time trend and an intercept. In Table 1 the study reports the results of the unit root tests without structural breaks. The results indicate that all the series were none-stationary at the levels since the probability values (0.9984, 0.9962, 0.3538 and 0.1976) were greater than 5% and therefore not statistically significant. In all cases of ADF and PP test of unit root the means and variance varied with time. However, these series exhibited stationarity at the 1, 5 and 10% level of significance after first differencing since the probability values (0.0753, 0.0003, 0.0002 and 0.0501) are less than 1, 5 and 10% respectively. As a result it can be concluded that all variables are *I (1).* The presence of stationarity in the series indicates that the means and variance as well as the autocovariance of the series are now stable and invariant with time. The time invariant property of the series is vital in specifying and estimating accurate model. If the series are time variant they will produce spurious results which induce wrong interpretation (Engle and Granger, 1987).

An examination of the plotted series in Figure 1 indicates the presence of structural break of one or more. These structural breaks may influence the tested unit roots results to accept the null hypothesis against the alternative hypothesis when structural breaks effects are not taken into consideration. The results will thus be spurious and any policy decision made on them will be misleading.

Therefore, this study takes into account structural breaks in examining the causality between economic growth and electricity consumption through the application of Zivot-Andrews (1992) and Perron (1997) methodologies. Tables 2 and 3 present the results of the unit root with structural breaks. The two test methodologies indicated that the series are $I(0)$ and $I(1)$.

The results in Table 3 indicate the null hypothesis of non-stationarity is rejected at the 5% level of significance at the first differences for both economic growth and electricity consumption. The structural break for first series occurred in 1979 and 1980 respectively. These estimated breaks for the economic growth correspond to the 1979 oil price shock which escalated the price of crude oil and made very difficult for the country to obtain oil input in sufficient quantities. Again, the year 1979 also witnessed a regime change with the coming into power of the Armed Forces Revolutionary Council (AFRC) which launched a vigorous campaign with the intention of cracking down on corruption. On the other hand the estimated structural breaks for electricity consumption occurred in 1983 and 1985 which correspond to a series of external shocks. First was the unprecedented drought and bushfires that smack food production and burnt down cocoa trees. Second, the world price of cocoa plummeted to its lowest level with the resultant deterioration in the terms of trade. Finally, about one million Ghanaians were expelled from Nigeria and brought back to Ghana which further worsened the already precarious situation. These events resulted into extreme food shortages and massive unemployment. In order to reverse the decaying economy the government adopted the World Bank and

Table 2. Unit root tests.

Variable	ADF		PP	
	Levels	First differences	Levels	First differences
Y	1.804 (0)	-2.692*** (0)	1.2260 (3)	-2.861*** (3)
EC	-1.854 (0)	-4.514* (0)	-2.224 (3)	- 4.384* (3)

The estimates in the parentheses are the lag order in the ADF and PP tests. The ADF lags are selected using the AIC while the Newey-West correction selected the PP lags length. * and *** indicate significance at the 1% and 10% levels respectively. The critical values were obtained from Mackinnon (1991).

Table 3. ZA (1992) unit root tests.

Variable	levels		First differences	
	$t_{\dot{\lambda}}(\dot{\lambda}_{\inf})$	Year of break	$t_{\dot{\lambda}}(\dot{\lambda}_{\inf})$	Year of break
Y	-0.036 (0)	1979	-4.702 $(0)^{**}$	1980
EC	-4.439 (1)	1983	-4.835 $(0)^{**}$	1985

The estimates in the parentheses are the selected lag order in the ZA tests. The lag orders were selected by employing AIC criterion. '**' indicates 5% significance levels.

Table 4. Clemente-Montanes-Reyes unit root test with structural breaks.

Variable	Innovative outliers				Additive outliers			
	t-stat	TB1	TB2	Decision	t-stat	TB1	TB2	Decision
Y	2.197 **	1982	2003	I(1)	-3.216*	1972	2002	I(0)
EC	-3.560*	-	2007	I(1)	-3.603*	1980	1987	+I(0)

*, and ** indicate significance at the 1 and 5% levels.

International Monetary Fund (IMF) economy recovery programme in April 1983. The structural break point of 1985 also correspond to the launch of the macroeconomic stability document of the IMF with the aim of removing all price controls such as subsidies on utility services and stabilizing the exchange rate. However, the ZA test lack the capability of indicating double structural points in the series. To solve this shortcoming this study employed Clemente-Montanes-Reyes structural break unit root test and report the results in Table 4. Clemente et al. (1998) modified the statistics of Perron and Volgelsang (1992) by integrating the assumption of two structural breaks models. The models are the additive outlier (AO) and innovative outliers (IO). The AO is the crash model and permits for an unexpected change in the mean while the IO model permits for gradual shifts in the mean. The null hypothesis of no structural breaks in the series is tested against the alternative of structural breaks. The unit root test in Table 4 produced mixed results.

The IO model indicates that economic growth and electricity consumption are both I (1) while the AO show that the series are I (0). This implies the null hypothesis was rejected when the series were I (1) for the IO model and rejected at the levels for the AO model. The cointegration decision is made when the series are I (1).

Results of cointegration test

Table 5 present the results of the Johansen maximum eigenvalue and trace tests for examining the cointegration relationship. Granger (1988) suggested that the existence of cointegration between economic growth and electricity consumption is an indication that causality exist between these variables in at least one direction.

The cointegration results of economic growth and electricity consumption indicate that both series move together in the long-run relationship. This is as a result of the null hypothesis of $H_0: r = 0$ against $r \leq 1$ was rejected

Table 5. Johansen test for cointegration.

Null Maximum eigenvalue test	Alternative	Statistics	95% critical value
r= 0	$r=1$	20.85	15.67
r ≤ 1	$r=2$	6.70	9.24
Trace test			
r= 0	$r\geq 1$	27.55	19.96
r ≤ 1	$r\geq 2$	6.70	9.24

The lag order 2 is selected based on the adjusted likelihood ratio and the test statistics are significant at the 5% level.

Table 6. Results of VECM Granger causality test.

Dependent variable	Wald statistic $\sum \Delta lnY_{t-1}$	Wald statistic $\sum \Delta lnEC_{t-1}$	t-statistic	ECT_{t-1}
ΔlnY_t	-	5.93	0.0023	-0.40644 (-3.5330)*
ΔEC_t	21.06^{*}	-	3.2911*	

'*' indicates the test statistics are significant at the 1% level. The appropriate lag lengths are chosen using Akaike's information criteria (AIC).

at the 5% level of significance in both the maximum eigenvalue and the trace tests. Therefore, The cointegration results of economic growth and electricity confirms the presence of a long-run equilibrium relationship between the series in Ghana. Since both series are *I (*1*)*, then the partial difference between them will be stable around a fixed mean. The implication would be that economic growth and electricity consumption are drifting together at roughly the same rate except for transitory fluctuations. Therefore, cointegration of economic growth and electricity consumption implies that both variables follow a common stochastic trend.

Results of Granger causality tests

The presence of cointegration between economic growth and electricity consumption confirms the existence of Granger causality at least in one direction. Nevertheless the presence of cointegration does not specify the direction of Granger causality between the series. To determine the direction of the causality the study analyzes the short run and long run results of the VECM specified in Equations 5 and 6 and report the results in Table 6. The Wald statistic indicates the short run causal effects between economic growth and electricity consumption while the t-statistic on the error correction term depicts the long run Granger causal effects. Beginning with the short run results it can be observed that the Wald statistic (5.93) for electricity consumption is statistically insignificant in the economic growth equation. There is therefore no short run causal relationship running from electricity consumption to economic growth. This implies that electricity consumption in the short run has a neutral effect on economic growth. However, the Wald statistic (21.06) for economic growth is statistically significant at the 1% level in the electricity consumption equation. This suggests that in the short run there is a unidirectional Granger causality running from economic growth to electricity consumption. Economic growth therefore, has a short run temporary impact on electricity consumption.

In the long run the same scenario is repeated for the economic growth equation. The corresponding t-statistic (0.0023) on the coefficient of the ECT is also insignificant suggesting that there is still no Granger causality running from electricity consumption to economic growth. However, in the electricity consumption equation the t-statistic on the error correction term (-3.5330) is statistically significant at the 1% level suggesting a long run Granger causal relationship running from economic growth to electricity consumption. There is therefore the presence of growth-electricity consumption hypothesis in Ghana and this is consistent with the results of Adom (2011).

The results have certain implications for the Ghanaian economy. First, electricity as a source of energy constitutes a small proportion of the aggregate energy consumption by the real sector of the economy of Ghana. A large part of the real sector depends heavily on oil and biomass as sources of energy for productivity. In 2010 the total energy consumed in Ghana was 249.9 (PJ) and out of this 36.6% was oil, 35.5% was biomass, 15.9% was charcoal and 12.5% was electricity consumed (Energy Commission of Ghana, 2010). Electricity consumption is therefore relatively insignificant compare to oil and biomass and as a result it does not have any substantial impact on the real sector of the economy.

Second, the distribution of electricity is biased toward the residential sector with relatively low tariff against the industrial sector. For instance in 2010 the distribution of electricity by the Electricity Company of Ghana witnessed 76.9% going to the residential sector while the mines accounted for only 14.1% (ISSER, 2010). This means that producers in the real sector of the economy may not have experienced any decline in their output even during periods of severe electricity crises such as in the 1998, 2006/2007. In the 2006/2007 fiscal year, despite the severe electricity crisis the economy of Ghana registered an unprecedented growth of 6.2% since two decades (ISSER, 2008). Also the agricultural sector in Ghana is still at the subsistence level with relatively very low utilization of irrigation and therefore very low consumption of electricity.

Finally, the failure of electricity to cause growth in the Ghanaian economy may be attributable to the cross subsidization policy of the government of the republic of Ghana. Household electricity prices are subsidized and partly funded by industry. This makes Ghanaian industries comparatively uncompetitive to their foreign counterparts. Hence they are unable to generate the expected growth. The households may also misuse electricity because they do not pay the market price hence stifling the needed growth brought about by the growth in electricity consumption.

Parameter stability and structural breaks

The Engle-Granger procedure to cointegration may under-reject the null hypothesis of no cointegration if there is a long-run equilibrium relationship that has changed at some unknown time during the sample period. This means that cointegration test that does not take into account of the break in the long run relationship may demonstrate a low power (Harris and Sollis, 2005). Gregory and Hansen (1996) provided an extension of the Engle-Granger model and allowed for a single break in the long-run relationship. This extension takes into account endogenous structural break in the cointegration vector and permits for three alternative models: (i) a level shift (model C), a level shift with a trend (model C/T), and a regime shift which permits the slope vector to also shift (model C/S). Gregory-Hansen propounded versions of Engle-Granger (1987) ADF cointegration tests and for the ZA and z_t test of Philips and Quliaris (1990). All these were amended to take account of the alternative model taken into consideration. Table 7 reports the results of the Gregory-Hansen test for regime shifts taken into consideration only the ADF, Za and Z_t tests.

The study reports the minimum estimates of the ADF to examine structural changes in the long-run relationship for the three models suggested by Gregory and Hansen. The break point for the three models and the ADF were: model C (-4.75, 1999); model C/T (-4.82, 1999); model C/S (-4.75, 1999) and the model: change in regime and trend (-4.87, 1999). Since the test statistics are significant at 5 and 10% levels for the first three models (C, C/T and C/S), the null hypothesis of no cointegration among the variables is rejected throughout. The significant break date is the same for the entire model. The break date corresponds to the 1999 regime change which witnessed the change from one political government to another. Contrarily, the study cannot reject the null hypothesis for the fourth model in the case of the ADF as well as all the models for the Zt and Za tests. The results therefore imply that there exist some levels of support for the presence of cointegration even with the identification of structural change.

CONCLUSIONS AND POLICY IMPLICATIONS

This study conducted an assessment into structural breaks, electricity consumption and economic growth for Ghana spanning 1970 to 2010 in a bivariate framework. The study used kwh per capita to denote total electricity consumption and real per capita income denote economic growth. The study allowed for structural breaks in the unit root and cointegration tests were conducted. The study sought to test Ghana's data for the past 41 years, during which the economy experienced a lot of economic restructuring as well as policy modifications that may have led to economic growth or electricity consumption producing structural breaks. The study also performed the cointegration and causality tests to ascertain the direction of Granger causal relationship between the series. The study drew a few conclusions from these estimations and tests. First, the acknowledgment of structural breaks brought some insightful results. The conventional unit root tests advocate that the series are $I(1)$ But the Zivot-Andrew advocates that unit roots are not present in the levels data when structural breaks are taken into account. Again, the conventional cointegration test advocates

Table 7. Gregory and Hansen (1996) test for regime shift.

Model	Test statistic	Break date	Asymptotic critical values		
C			**1%**	**5%**	**10%**
ADF	-4.75**	1999	-5.13	-4.61	-4.34
Zt	-4.11	2001	-5.13	-4.61	-4.34
Za	-21.31	2001	-50.07	-40.48	-36.19

Model	Test statistic	Break date	Asymptotic critical values		
$^{C}/_{T}$			**1%**	**5%**	**10%**
ADF	-4.82***	1999	-5.45	-4.99	-4.72
Zt	-4.12	2001	-5.47	-4.99	-4.72
Za	-21.90	2001	-57.28	-47.96	-43.22

Model	Test statistic	Break date	Asymptotic critical values		
$^{C}/_{S}$			**1%**	**5%**	**10%**
ADF	-4.75***	1999	-5.47	-4.95	-4.68
Zt	-4.13	2001	-5.47	-4.95	-4.68
Za	-21.73	2001	-57.17	-47.04	-41.85

Model: Change in regime and trend	Test statistic	Break date	Asymptotic critical values		
			1%	**5%**	**10%**
ADF	-4.87	1999	-6.02	-5.50	-5.24
Zt	-4.22	1998	-6.02	-5.50	-5.24
Za	-22.78	1998	-69.37	-58.58	-53.31

The lag order (1) was selected using the AIC procedure.** and *** indicate 5 and 10% significance level.

the presence of one cointegration vector and the Gregory-Hansen technique confirms the presence of cointegration relationship between the series at both 5 and 10% significance levels respectively.

Second, the results indicate the existence of unidirectional causality which runs from economic growth to electricity consumption. The Granger causality running from economic growth to electricity consumption implies economic growth precede electricity consumption in Ghana. This suggests that electricity preservation policies such as demand side management policies, the use of energy saving bulbs and minimum efficient standards measures to drastically reduce electricity wastage may be implemented without adversely affecting economic growth. This conclusion is consistent with Adom (2011) finding of Granger causality which runs from economic growth to electricity consumption using a bivariate cointegration within Toda-Yamamoto framework. Therefore the neutrality hypothesis between economic growth and electricity use does not hold in Ghana.

Since the empirical evidence suggest that economic growth positively and directly affect electricity consumption implies that (i) Ghana's real sector to a large extent does not depend on electricity usage for high level productivity (ii) any negative shock to the electricity sub-sector such as astronomical increase in electricity prices or reduction in electricity supply will not negatively impact on productivity. For electricity usage to generate positive impact on economic growth there is the need to gear policy towards the abolition of the household prices or reduction in electricity supply will not usage towards the manufacturing sector. This may help industry to be competitive and the households will also reduce their inefficiency which may result in the needed growth that comes with electricity consumption in the Ghanaian economy.

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