International Journal of Economics, Commerce and Management
United Kingdom Vol. IV, Issue 2, February 2016
http://ijecm.co.uk/ ISSN 2348 0386

A DYNAMIC ESTIMATION OF ELECTRICITY PRODUCTION AND ECONOMIC GROWTH IN GHANA

AN ECONOMETRIC ANALYSIS

Samuel Kwaku Adjei
Garden City University College, School of Business,
Department Of Economics and statistics, Kenyase - Kumasi, Ghana
skadjei30@gmail.com

Abstract

The need to generate sufficient power for industrial, commercial and residential use to facilitate economic growth and development has been a growing concern in Ghana's quest for economic growth. The paper was to do a dynamic analysis of the effect of electricity production on the GDP Per Capita growth in Ghana- to examine both the long-run effects and the short-run dynamics, investigate the speed of adjustment to the long run equilibrium and also to explore the direction of causality, if any, of GDP Per Capita growth and electricity production in Ghana, by using world Bank Data, spanning from the year 1971-2013. The Co-Integration Methodology was used; where the Fully Modified Ordinary Least Squares (FMOLS), Dynamic Ordinary Least Squares (DOLS), and the Vector Error Correction Model (VECM) were estimated. The study found a positive and significant relationship between electricity production and GDP per capita growth rate in Ghana in the long run estimates. The rate of adjustment back to the long run equilibrium when there is a disturbance in the short-run dynamics was -0.796939 suggesting a relatively faster speed of adjustment back to the long-run equilibrium, when there is any disturbance. The result suggests that about 80% of the deviation between the actual and the long-run equilibrium value of Electricity Production and GDP Per capita growth rate is corrected each year. Result also showed a unidirectional causal relationship running from GDP growth to electric power consumption per capita.

Keywords: Electricity, Gross Domestic Product, Cointegration, Vector Error Correction

INTRODUCTION

The need to maintain a sustainable level of energy supply for economic growth and development is very significant in every economy; Policy makers adopt different strategies to increase the energy supply to spur industrial growth; however, the relevant threshold of energy supply for any economy depends on the natural resources availability, population density, long term economic goals for the state and its institutional strength ,the quality of energy policies formulated by the experts and the political will to implement the formulated policies for industrial growth and sustainable economic development.

The main objective of the paper is to investigate both the short and the long run relationship between GDP growth and electricity production in the Ghanaian economy and to explore the speed of adjustment to restore equilibrium any disturbance, experienced in the short run dynamics of the local economy; as well as examine the causal relationship between GDP growth rate and electricity production in the Ghana and the policy implications involved.

The fundamental driver of economic growth and development is the constant supply of quality and reliable energy supply and so countries must develop their own energy programs in careful and sustainable ways. Access to environmentally and socially sustainable energy is essential to poverty reduction on the continent.

More than 1.4 billion people are still without access to electricity worldwide, almost all of whom live in developing countries. About 2.5 billion use solid fuels—wood, charcoal, and dung—for cooking and heating. Economic growth in most countries is driven by successful industrial activities (extractive and manufacturing), alongside agriculture and services.

Governments can play a major role in all phases of industrial development and maturity, through regulatory policies. It is not mere coincidence that china and USA are acclaimed as serous economies in the world; World Band figures available indicate that in 2012, China consumed 4693,000,000MW.h/yr. with 395MW.h/yr. per capita, this figures were followed by United State of America with 3886400,000MW.h/yr and 1402 MW.h/yr. per capita.

Same cannot be said about developing nations such as Ghana's 6060,000MW.h/yr, with 29MW.h/yr. per capita in 2010 has a positive correlation with economic growth and development. The key and the fundamental issues in Ghanaian Power Sector include the following, low access to electricity ,inequity and insufficient capacity, Poor reliability ,High costs, high level of inefficiencies from both producers and consumers of power, lack of clear political will to develop sustainable power systems to power industries etc. The rapid expansion in economic activities in Ghana has led to an ever increasing demand for power, however, demand far outstrips supply in the economy. This is due to high population growth rate, inflow of foreign investors, an increase in economic activities and an over reliance on foreign countries for sources of energy generation and so on (Enu, 2014). This has led to shortages leading to rationing of the power supply, popularly known in the local parlance as “Dumsor” (load shedding) which has negatively affected economic activities.

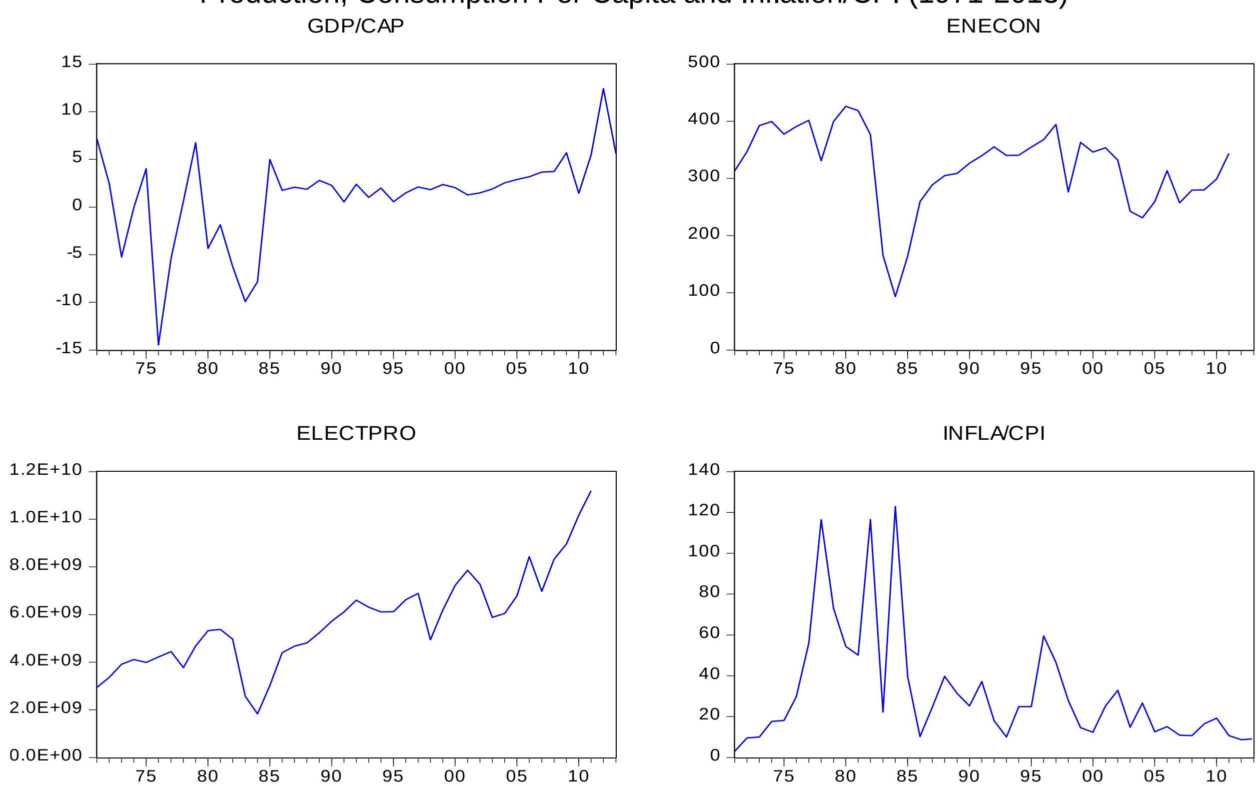
DESCRIPTIVE STATISTICS AND TREND ANALYSIS OF VARIABLES

Using trend analysis, we discuss the effect of power production on economic growth in Ghana with WDI data from 1971-2013. In doing this, the study placed emphasis on, indicators such as GDP per capita, Electricity Consumed Per Capita, Inflation /CPI, and Electricity Production to industries.

Table 1. Descriptive Statistics Of The Indicators and Trend Exhibited by GDP/Capita, Electricity Production, Consumption Per Capita and Inflation/CPI (1971-2013)

INDICATORS	**MEAN (%)(Average)**	**STANDARD DEVIATION**	**MINIMUM**	**MAXIMUM**
GDP Per Cap Rate(Index)	1.140078	4.729262	-14.45490	12.42247
ELECT PRODUCTION	5.7209	1.9909	1.8309	1.1210
ELECT CONSUMPTION	320.8342	71.65374	93.48751	425.9200
INFLATION/CPI	31.63969	28.84950	3.030303	122.8745

Table 1. Descriptive Statistics Of The Indicators and Trend Exhibited by GDP/Capita, Electricity Production, Consumption Per Capita and Inflation/CPI (1971-2013)



Source: Author’s Calculations using data from World Bank WDI Database.

A proper analysis of electricity production and its effect on GDP Per capita growth rate in Ghana with the selected indicators could be done by first looking at the pattern and trends of these variables over the years specified for the study using trend analysis. This would be of much help in an attempt to get a clear graphical idea of the behavior of these variables over time. These trends are shown in the graphs displayed in Figure 1 (see appendix). Also shown in Table 1 are descriptive statistics of these selected indicators for the period under study.

Trends In GDP/ Per capital Growth Rate In Ghana Over The Period 1971 – 2013.

As shown in Figure 1, GDP per capita growth rate in Ghana has not generally shown an upward trend actually ,and exhibited sharp fluctuating trend over the period under study, particularly 1971-1985 and virtually taking a level trend 1985-2005. In spite of the fluctuations, GDP/capita growth rate averaged at 1.14, as the annual growth rate between 1971 and 2013, with the highest per capita growth rate of 12.4, as the annual percentage growth. From 1971 to 2013, notwithstanding the significant annual growth rated registered, there was a consistent reduction in Per capita GDP annual figures from 12.4 percent to -14.45 percent which was the lowest recorded during the period under consideration.

Trends In Electricity Production In Ghana Over The Period 1971 – 2013.

The rate of electricity production in Ghana has generally shown an upward trend , the upward trend was recorded between 1971-2013, irrespective of the drop in trend from 1980-1985, and could be as a result of the heavy drought experienced in the economic history of the nation. The annual production rate averaged at 5.7209, as the annual growth rate between 1971 and 2013, with the highest growth rate averaging about as 1.12 per kw annually from 1971 to 2013.

Trends In Electricity Consumption Per capita In Ghana Over The Period 1971 – 2013.

The rate of electricity consumption per capita in Ghana has not generally shown an upward trend just like the GDP Per capita, the upward trend was recorded between 1971-1980, and this was followed by a sharp drop in trend around 1980-1984, this phenomenon could equally be attributed to the heavy droughts experienced in the history of the economy; however, electricity consumption per capita took an upward trend again from 1985-1995, and has since exhibiting the downward trend to date. The per capita consumption rate averaged at 320.8, as the annual growth rate between 1971 and 2013, with the highest growth rate averaging about as 425.9 and the lowest per capita consumption rate of 93.5 annually from 1971 to 2013.

Trends In Inflation/CPI In Ghana Over The Period 1971 – 2013.

The rate of inflation in Ghana has exhibited a sharp fluctuations over the period of 1971-1985; after which inflation took a relatively downward trend from 1985-2013. The highest rate of inflation was recorded between 1971-2013 was 122.9 percent of GDP between 1982-1985; this could be as a result of the severe droughts, following a massive destruction of the country's forest cover and the influx of the Ghanaian nationals deportees from Nigeria, that increased the demand for consumables in the economy. Within the period under study, the least recorded rate of 3.03 percent; and inflation has seen a relatively downward trend , thought with sharp fluctuation in figures over the years.

LITERATURE REVIEW

Some major factors mostly outlined by economic growth theorists as factors influencing growth include the following; capital, labor, land, technology, government spending, foreign direct investment, foreign aid, interest rate, exchange rate, taxations, institutions, etc (Enu, 2014).

And recently energy, (see Solow, 1956; Lucas 1988; Grossman and Helpman 1990 & 1991; Romer, 1990, 2007; Aghion and Howitt, 1992; Aryes and Warr, 2009; Acemoglu et al., 2006; Aghion et al., 2006; Holmes and Schmitz, 2001). Primary inputs of production are inputs that exist at the beginning of the production period under consideration and are not directly used up in production (though they can be degraded and can be added to) while intermediate inputs are those created during the production period under consideration and are used up entirely in production (Vlahinic-Dizdarevic and Zikovic, 2010),(Enu, 2014). The role that energy plays in an economic growth and development of a country has attracted a lot of research attention.

However, about 99% of the studies done on energy and economic growth have only concentrated on the causal relationship between energy consumption and economic growth (Enu, 2014). (Kraft and Kraft, 1978; Akarca and Long, 1980; Erol and Yu, 1987; Mozumder and Marathe, 2007; Shiu and Lam, 2004; Jumbe, 2004; Oh and Lee, 2004; Ghosh, 2002; Enu and Havi, 2014), while the remaining 1% attention is paid to the relationship between energy production and economic growth (see Filiz et al, 2012; Morimoto and Hope, 2001); (Enu, 2014). From a study conducted by Filiz et al. (2012) energy production can leads to economic growth and economic growth can also lead to energy production. This means that as energy production increases economic growth will also increase or economic growth will increase as the energy production increases (Enu, 2014).

Yemane Wolde-Rufael (2004) tested long-run causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita for 17 African countries for the period 1971 to 2001. The study employed cointegration test proposed by

Pesaran et al. (2001) and a modified version of Granger causality test developed by Toda and Yamamoto (1995). Results of this empirical work showed that there exist a long-run relationship between electricity consumption per capita and real GDP per capita among 9 of the countries studied and Granger causality for 12 countries out of the 17 studied.

ELECTRICITY USAGE IN GHANA

With customer base of approximately 1.4 million, it has been estimated that 45 -47 % of Ghanaians, including 15-17 percent of the rural population, have access to grid electricity with a per capita electricity consumption of 358 kWh. All the regional capitals have been connected to the grid, Institute Of Statistical, Social And Economic Research (ISSER), report (2005). Electricity usage in the rural areas is estimated to be higher in the coastal (27 percent) and forest (19 percent) ecological zones, than in the savannah (4.3 percent) areas of the country. In 2004, Ghanaians consumed 5,158 gigawatthours (GWh) of electricity. It is estimated that about half of this amount is consumed by domestic (or residential) consumers for household uses such as lighting, ironing, refrigeration, air conditioning, television, radio and the like. Commercial and industrial users account for the rest. The majority of the customers are in service territories of the Electricity Company of Ghana (ECG) and the Northern Electrification Department (NED) and they are regulated However, there are also deregulated consumers such as mines, and aluminum companies, which account for one third of total consumption. One industrial entity, VALCO, can account for most of this amount when it is operating normally. This consumer-class typically uses a number of high energy consuming household appliances and items such as air conditioners, fridges, water heaters, electric cookers in addition to a substantial amount of lighting equipment and bulbs for the houses, ISSER,(2005). The majority of the rest of the residential consumers use electric power for lighting. Since the 1980's, the government has pursued a policy of extending electricity to the rural communities; this is to encourage the use of electricity for productive use for cottage industries and eventually the growth of these industries into bigger consumers which will become a source of employment and economic growth for the communities they are situated in, ISSER,(2005).

RESEARCH METHODOLOGY

Type and Sources Of Data

This descriptive researcher used secondary data to achieve the objectives of this study. The secondary source made use of annual time series data for the period 1971 – 2013 obtained mainly from the World Bank (World Development Indicators) and the Bank of Ghana Statistics. For the estimation of models specified in the methodology.

This study mainly employs three methods in examining causal relationship between electricity consumption and GDP growth and the magnitude of the effect for the Ghanaian economy as identified by Enu, (2014). In order estimate these effects or relationships, annual data was used. Electric energy consumption and GDP growth data are sourced from the World Bank country database. The rest of this section is organized as follows:

First, electric energy consumption and GDP growth variables are tested for unit root to establish the extent to which the variables meet necessary stationary conditions, using the ADF-test. Second, both the long and the short run coefficients and it error correction equation were estimated and finally, the Granger causality test is conducted to ascertain direction of causality if any, between the two main variables in this study; GDP Per capital Growth and Economic Growth in Ghana.

To overcome a possible occurrence of spurious regression results due to nonstationary time series data, this study verifies stationary conditions of the test variables. The goal is to show that the variables (GDP per capita growth and electric production) are integrated in the order I(0) or a linear combination of the variables are cointegrated in a similar order; Engle and Granger,(1987). Stationary properties of electric energy production and GDP growth variables are evaluated using the Augmented Dickey-Fuller Unit root test procedure.

Granger causality test is conducted using F-test manipulation of ordinary least square regression analysis. Choice of appropriate lag time use in conducting Augmented Dickey-Fuller test as well as Granger causality test is based on the Akiake Information Criterion (AIC) procedure and the Schwartz/Bayesian Information Criterion (SBIC). The following section presents the framework for various tests conducted; the empirical estimation procedures and findings, conclusion and recommendations made.

The General Model

The function in its general form for this study can be written as:

GDP Per Cap =f (ELECTRICITY PRODUCTION, ELECTRICITY CONSUMED PER CAPITA AND INLATION/CPI)…………………………………………………………...(1)

Variables Description

GDP PER CAP = Gross Domestic Product per capita

INFLATION= Represents inflation level , It represents annual percentage change in cost of average consumer acquiring fixed basket of good measured by the consumer price index.

ELECTRICITY PRODUCTION (kWh/capita)= In kWh of oil equivalence.

ELECTRICITY CONSUMPTION PER CAPITA(kWh/capita)= In kWh of oil equivalence per capita by final user, i.e. power which is not being used for transformation into other forms of energy. Data were obtained from World Bank Statistics- WDI, 2014.

Empirical Estimations Framework

The estimable econometric model in log-linear form can be specified as;

$$GDP_i = AELECPROi^{\beta 1}\ ELECONi^{\beta 2} INFLAi^{\beta 3} ei^{\varepsilon} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.... (2)$$

$$LnGDPt = lnA\beta t0+\beta 1LnELECPROt+\beta 2LnELECONt+\beta 3LnINFLAt+ \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots.(3)$$

Equation (3) above represents the long run equilibrium relationship. (Where βi = 1, 2 and 3) represents the elasticity coefficients, ε is the error term, t is time trend and *Ln* denotes natural logarithm. All the variables to be examined are in natural logarithm form. The choice of the log-linear model was based on the premise that log transformation allows the regression model to estimate the percentage change in the dependent variable resulting from the percentage changes in the independent variables (Stock and Watson, 2007). The log-linear model also helps reduce the problem of heteroskedasticity in that it reduces the scale in which the variables are measured from a tenfold to a twofold, creating uniformity in measurement of variables (Gujarati, 1995).

A Priori Expectation of Variables

A broad and comprehensive review of the literature on the relationship between electricity production and GDP growth show that there are theoretical models that postulate both positive and negative effects of power on economic growth (Enu, 2014), depending on the economic dynamics in the period under consideration. Therefore the signing of the coefficient of both β_1 and β_2 cannot not be determined apriori; however, that of β_3 is expected to be signed negative indicating that if inflation increases, GDP growth falls, all things being equal; $\beta_1 < 0$.

Econometrics Estimation Techniques

This section provides methodology framework for the study. Arize et al. (2008) suggest that the multivariate analysis may lead a precise analysis in order to capture the long run and short run relationships between the variables. Therefore, in order to capture these issues, the study applied both Co Integration analysis and Error Correction Model. However, before we go further, the beginning of a multivariate analysis for time series data lies in the univariate unit root tests. Therefore the study performed the unit root tests proposed by Dickey and Fuller (1979).

Unit Root Tests

The study begun the analysis by estimating the unit root test proposes by Dickey (1976), Fuller (1976), The well-known Augmented Dickey Fuller tests use a parametric auto regression to approximate the ARMA structure of the errors in the test regression..

This helped to checked the stationarity of the data, otherwise ordinary least square may generate spurious results. The study used the Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981) to find the unit root problem in data, which is an indication for non stationarity of data. The ADF test is based on the following general equation:

$(1-L)Yt = \alpha 0 + \mu Yt\text{-}1 + \sum_{i=1}^{k} \beta i(1-L)Yt - i + \varepsilon t$……………………………….4

Where, L is a lag operator, t denotes time trend, and εt is a white noise error term. Yt denotes the variables for which study is testing unit root problem. *Y*t-i are the lagged values of variables of our study. *βi* are the coefficients of lagged values of *Y*t-i to capture the optimum lag length (k), k ensures that there is no correlation between error term and regressors of this equation. Lag length is selected by SIC (Schwartz Information Criterion). The equation is only with constant *α* and includes also time trend *γt* afterward along with constant. ADF test checks the statistical significance of *μ,* if *μ* has statistically zero value then *Yt* has unit root problem and is non-stationary. If *μ* is not statistically zero then there is not a problem of unit root and *Y t* is stationary over time.

Lag Order Selection In Vector Autoregressive Models

Appropriate selection of lag order gives the reliable results of the analysis. On the other hand, if the selection of the lag order is not appropriate, then the results of the study will be biased and the residual can be serially correlated. In this paper, the Schwartz test was used to overcome the problem of the lag order. This procedure removes arbitrariness in choosing the maximum lag length in the test; If the chosen lag length is less than the true lag length, the omission of relevant lags can cause bias. If the chosen lag length is more, the irrelevant lags in the equation cause the estimates to be inefficient. (Bhattacharya & Mukherjee).

The importance of lag length determination is demonstrated by Braun and Mittnik (1993) who show that estimates of a VAR whose lag length differs from the true lag length are inconsistent as are the impulse response functions and variance decompositions derived from the estimated VAR. Lütkepohl (1993) indicates that overfitting (selecting a higher order lag length than the true lag length) causes an increase in the mean-squareforecast errors of the VAR and that underfitting the lag length often generates autocorrelated errors.

Co Integration Test (Johansen Maximum Likelihood Test)

After the selection of the lag orders and the stationarity test of the variables, the co-integration of the variables is checked. Johansen co integration test was conducted in order to check whether the selected variables are co integrated following (Khan, Sattar and Rehman, 2012), estimation of co-integration equation.

The Johansen (1991) maximum likelihood test was used to test the co-integration between Exchange rate, final household consumption, final government consumption expenditure, firms investment in fixed capital and inflation, That means it examines, whether the series are driven by common trends (Stock and Watson, 1988) or, equivalently, whether they are co-integrated (Engle and Granger, 1987). The test is based on the following equation of the VAR model.

$Xt = \delta 1Xt\text{-}1 + \delta 2Xt\text{-}2 + \ldots + \delta kXt\text{-}k + \varepsilon$ ……………………………………………5

Where Xt is the vector of non-stationary I (1) variables; δ1, δ2, .. δk are the parameters; ε is the vector of random errors which is distributed with zero mean and Ω variance matrix. The model can be further rewrites as: Rehman, et al (2012).

$\Delta Xt = \theta Xt\text{-}1 + \sum_{i=1}^{p-1} \lambda \Delta X t\text{-}1 + \varepsilon t$…………………………………………. …….6

Where, $\theta = \sum_{i=1}^{p} \lambda \delta i - Ii$ ………………………………………………………..7

And $\lambda = \sum_{j=1}^{p} \lambda \delta j$………………………………………………………………..8

The Granger representation theorem asserts that if the coefficient matrix θ has reduced rank r < x, there exists x X r matrix ω and Ω each with rank r such that θ = ωΩ’ and Ω’Xt is stationary. r is the number of co integrating relations (the co integration rank) and each column of Ω is the co-integrating vector. The elements of ω are known as the adjustment parameters in the vector error correction model. Johansen’s method is to estimate θ matrix in an unrestricted form, the test whether we can reject the restrictions implied by the reduced rank of θ.

The Johansen test put forward two likelihood ratio tests namely; the trace test and the maximum eigenvalue test. The trace test tests the null hypothesis of *R* co-integrating vectors against the alternative hypothesis of *n* co integrating vectors.

The test statistic is given by the following equation;

$J_{trace} = -T\mathit{ln} \sum_{i=r+1}^{n} (1 - \lambda^{\wedge} i)$ ………………………………………………………..9

The maximum eigenvalue tests the null hypothesis of *r* co integrating vectors against the alternative hypothesis of *n* co-integrating vectors. The test statistic for the maximum eigenvalue test is computed by the following formula:

$Jmax = -T\mathit{ln}\,(1 - \lambda^{\wedge}{}_{1+r})$ …………………………………………………………...10

T denotes the sample size and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation. None of the tests above follows the chi square distribution but rather a different distribution tabulated by Johansen and Juselius (1990) and are also provided by most econometric softwares (Hjamarsson and Osterholm, 2007).

Cointegration, a multivariate technique, occurs between two or more time series variables, if one or more linear combinations of different nonstationary time series produce stationary time series (Engle and Granger, 1987). The linear combination produces the long run relationship between different time series because it is a description of the lasting effects shared by the different time series (Johansen, 1995). The long run relationship, as a statistical measure, means the variables move together over time so that short term disturbances from the long term trend will be corrected. A lack of co-integration suggests that such variable have no long run equilibrium relationship and in principle, they can wander arbitrarily far away from each other (Dickey et al., 1991).

The Johansen (1991) maximum likelihood test is used to test the co-integration between Exports, and Exchange rate in the Ghanaian economy That means it examines, whether the series are driven by common trends (Stock and Watson, 1988) or, equivalently, whether they are cointegrated (Engle and Granger, 1987). The test statistic is used as follows;

The Vector Error Correction Model

General Specification Of Model

In order to apply the Johanson test procedure for co-integration to obtain estimates of all the short-run parameters from the VAR:, the following conditional VECM was estimated between exports and its determinants

The Johanson (1995) VECM equation can be written as

$\Delta Yt = \alpha\beta' Yt\text{-}1 + \sum_{i=1}^{p-1} \Gamma i \Delta Yt\text{-}I + V + \delta\ t + W1S1 + \ldots + WmSm + \varepsilon t$……………………….11

Where, Yt is K x 1 vector of endogenous variables, α is K x r matrix of parameters, β is K x r matrix of parameters, Γ1……Γp-1 are K x K matrices of parameters,

V is a K x1 vector of parameters, δ is a K x1 vector of trend coefficients, t is a linear time trend.

S1……Sm are orthogonalized seasonal indicators specified in the indicators option, and W1……Wm are K x 1 vectors of coefficients on the orthogonalized seasonal indicators.

There are two types of deterministic elements in (11): the trend, v + δt, and the orthogonalized seasonal terms, W1S1+…+ WmSm. Johansen (1995, chap. 11); shows that inference about the number of co-integrating equations is based on nonstandard distributions and that the addition of any term that generalizes the deterministic specification in (11) changes the asymptotic distributions of the statistics used for inference on the number of co-integrating equations and the asymptotic distribution of the ML estimator of the co-integrating equations.

Causality Test (Granger)

Granger proposed the causality test in 1969 to test whether one economic variable can help forecast another economic variable (Granger, 1969). This test is used to examine whether the past value of a variable series X, will help to predict the value of another variable series at present, Y; taking into account the past value of the Y (Granger, 1988).

Specifically, Granger causality from X to Y is established when the coefficients of the lagged difference of X are found to be jointly statistically significant and therefore help explain and predict Y , over and above what the lagged differences of Y can predict (Yaqiong Li, Lihong Huang). Since the variables are non-stationary, integrated at order 1, but not cointegrated, the appropriate model for testing the Granger Causality will be a VAR model using first difference forms of the variables in the following form as suggested by Granger (1980,1986, 2000) & Ben-Zion et.al.(1996.)

$\Delta Yt = \theta_0 + \sum_{i=1}^{n} \theta_{1i} \Delta Y_{t-i} + \sum_{j=1}^{m} \theta_{2j} \Delta X_{t-i} + \Psi_{1j} \varepsilon_{t-1} + \mu_t$ ……………………………………….....12

$\Delta Xt = \delta_0 + \sum_{i=1}^{n} \delta_{1i} \Delta X_{t-i} + \sum_{j=1}^{m} \delta_{2j} \Delta Y_{t-j} + \Psi_{2i} \varepsilon_{t-1} + v_t$……………………………………………………13

Where

Yt represent exports and Xt the explanatory variables respectively. n and m are the optimum lags. μt and vt are error terms.

In the Granger Causality test regression equations above; *X* does not Granger cause *Y*, if parameters on the lagged differences on *X* in equation (12) are jointly zero and *Y* does not Granger cause *X* if parameters on the lagged differences on *Y* in equation (13) are jointly zero.

These form the null hypothesis;

1) $H_0 : \theta_{21} = \theta_{22} = \theta_{24}$ …….. $\theta_{2m} = 0$, X does not Granger cause Y,

This implies that any of the explanatory variables does not Granger cause exports

2) H0 : $\delta_{21} = \delta_{22} = \delta_{23}$ ……….$\delta_{2m} = 0$, Y does not Granger Cause X

The results of the test are interpreted as follows:

The rejection of the first hypothesis implies X Granger cause Y, rejection of the second hypothesis implies Y Granger Cause X, concurrent rejection of the two hypotheses indicates bidirectional causality, acceptance of both indicates there is no causal relationship between X and Y, if the first hypothesis is accepted and the second rejected, there is a unidirectional causality from the X variable to the Y variable, and if the first hypothesis is rejected and the second accepted, then causality runs unidirectional from Y to X.

EMPIRICAL RESULTS AND DISCUSSION

This section presents the analysis and discussion of the results for the study. The chapter is made up of six sections. The first section presented the descriptive analysis of the effect of exchange rate on exports in Ghana. The second section deals with Unit Root testing results and followed by the Engel-Granger Co-integration test.

Presentation and discussion of the results of the Long Run estimates using the Full-Modified OLS and the Dynamic OLS procedure were done in the third section. Section four deals with error correction model constructed to analyze the short-run dynamics and error correction term identified, the ECM generally provides the means of reconciling the short-run behavior of series of economic variable with its long-run behavior. Section five deals with Granger Causality test, and other diagnostic tests of the study respectively.

Augmented Dickey-Fuller Test For Unit Root

The time series features of the variables were investigated to determine the order of integration of the choice variables. The existence of unit root in a variable implies non-stationarity and estimations based on non-stationary variables are very likely to lead to the production of spurious results (Granger, 1969).

Nonstationarity is very common to most time series variables and in order to avoid spurious results from the regression models estimated, the test for stationarity of variables was conducted. The study applied the Augmented Dickey-Fuller (ADF) test introduced by Dickey and Fuller (1979) to perform the unit root test by estimating equation (4). The ADF test involves testing the null hypothesis of nonstationarity (presence of unit root) against the alternative hypothesis of stationarity (no unit root).

Table 2. ADF Unit Root Test Results

ESTIMATES	LEVEL		FIRST DIFFERENCE	
VARIABLE	**Constant**	**Constant And Trend**	**Constant**	**Constant And Trend**
LnGDP/CAP	-0.614212**	-0.614212***	-3.079786***	-3.079253***
LnINFLA	-0.424173	-0.726743***	-1.537873***	-1.545002***T
LnELECPRO	-0.031293	-0.454754**	-0.918543***	-0.933460***
LnELECONS	-0.389025**	-0.423261**	-0.889464***	-0.888484***

Note: *,**,***, denotes the rejection of the null hypothesis of unit root at the 10%, 5% and 1% significance levels respectively. The critical values for the ADF tests statistics are -3.159, -3.46 and -4.076 at the 10%, 5% and 1% significance levels respectively. . The lag length in the ADF test is based on Schwarz Information Criterion. Results were obtained from Eviews 9.0 econometric software.

Source: Author's Calculations using data from World Bank WDI Database

At the level (constant only) all the variables were non-stationary, for instance, inflation and electricity production. The variables were then tested again by adding trend and some became stationary both at 1% and5% significant level. At the first difference without trend and with trend all the variables were found to be stationary. at 1% level of significance .with exception of the exchange rate which was found to be significant at 10% significant level.

The results therefore show that some of the variables are log level nonstationary and therefore exhibit unit root. They however achieved stationary after first differencing, all these series are stationary around a deterministic trend.. This therefore implies that the series are both I(0) and, I(1) series; and all series achieve stationarity after first differencing with constant and trend.

The economic implication of the presence of unit roots in the data is that shock to any of the variables will have a permanent effect; Mean reverting mechanism is absent in all the variables. As pointed above, the statistical implication for the presence of unit root is that it could lead to estimation of spurious regression relationships, unless the underlying series are co-integrated; therefore the study proceed to test for the existence of cointegration based on the Johanson maximum likelihood test framework. The results of the cointegration test are presented in Table 3. Now that it has been established that all the variables are integrated of order one, the study goes ahead to test for cointegration based on Johansen and Juselius (1990).

Cointegration allows for the testing of the long-run equilibrium relationships (cointegration) among the series. At the 5% level of significance, both the trace and maximum eigenvalue tests indicate two cointegrating equation (CE) among the variables. Thus, the null hypothesis of no cointegration relationship among the variables is flatly rejected at the 5% level of statistical significance, by both the trace test and the maximum eigenvalue test. The optimal lag length of one was selected based on SIC.

Table 3 presents the Johansen Cointegration test (both the trace and the Max-Eigen value test) results for all the variables (per capita GDP, Inflation rate, Electricity production and Electricity consumption) in the study.

From the estimation below in the table, it could be observed that the trace statistic of 85.55944 > the critical value of 47.85613 for the first equation, and again, 24.20238 is greater than 27.58434, for the second equation and very significant p-values of 0.0001 and 0.0179 respectively, indicate the existence of cointegration and leads to the rejection of no cointegration hypothesis.

Table 3. The Johansen Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.707072	85.55944	47.85613	0.0000
At most 1 *	0.462364	37.67408	29.79707	0.0051
At most 2	0.262166	13.47170	15.49471	0.0986
At most 3	0.040547	1.614301	3.841466	0.2039
Johansen Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.707072	47.88536	27.58434	0.0000
At most 1 *	0.462364	24.20238	21.13162	0.0179
At most 2	0.262166	11.85740	14.26460	0.1161
At most 3	0.040547	1.614301	3.841466	0.2039
Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level, **MacKinnon-Haug-Michelis (1999) p-values				

Source: Author's Calculations using data from World Bank WDI Database.

Co-Integration Coefficient Results Of FMOLS and DOLS

The study applied Pedroni's (2000) FMOLS and DOLS methods to estimate final unbiased coefficients of this relationship and test the consistency of estimators with expectations following the co-integration tests. The FMOLS method corrects the biases of estimators with standard fixed effects which are rises from problems such as autocorrelation and heteroscedasticity, while DOLS process will correct biases of static regression which are arisen from endogeneity problems by including dynamic considerations to the model (Kök et al., 2010, Bayar et al, 2014).

Table 4. Result Of The Long Run (FMOLS & DOLS) and Short-Run Estimates

Dependent Variable: LnGDP/CAP				
VARIALBES	***L.R COEFFICENTS***	***STD ERRORS***	***T- STATS***	***P-VALUES***
FMOLS				
LnINFLA	-0.035873**	0.014973	-2.395776	0.0119
LnELECPRO	8.9410***	2.2510	3.973341	0.0001
LnELECONS	-0.007125	0.005589	-2.395776	0.2105
DOLS				
LnINFLA	0.005512	0.022300	0.247193	0.8068
LnELECPRO	1.4509***	2.9810	4.846449	0.0001
LnELECONS	-0.010806	0.007249	-1.490644	0.1486
VARIABLES	***S.R COEFICIENTS***	***STD ERRORS***	***T-STATS***	***P-VALUES***
LnINFLA	0.047510**	(0.01424)	[3.33746]	0.0010
LnELECPRO	-1.0309***	(2.010)	[-5.04869]	0.0001
LnELECONS	-0.006165	(0.00449)	[-1.37377]	0,1598
VEC TERM	-0.796939			

Note: The rejection of the null hypothesis was set at the 5%, significance levels of the Two-tailed, with t-critical 1.960. Results were obtained from Eviews 9.0 .L.R=Long Run. S.R=Short Run. VEC=Vector Error Correction.

As shown in Table 4 above, inflation in the long run, has a negative and very significant impact on GDP growth rate. From the long run elasticity coefficient estimated; it could be observed that a unit increase in inflation will lead to approximately, 0.04 reductions in the GDP per capita growth rate. Compared this with the short run coefficients estimated, it is interesting to note that in the short run, increase in inflation level, will lead to an increase in the GDP per capita growth rate, this revelation is analogous to Frimpong and Marbuah (2010), who found that some level of inflation is required to trigger private sector investment to take advantage of relatively higher prices in order to increase their profit margins on the market, which will have a significant positive effect.

However, a long and consistent inflation pressures will eventually increase the user cost of capital and reduce private investment (Eshun et al, 2014); and this creates a negative consequences on GDP growth rate in the economy. The elasticity coefficient estimated for the electricity production variable was positive and very significant at 1 percent error level. Here, it was revealed that a unit increase in electricity production will in the long run increase GDP growth rate by 8.9410 units.

This revelation is consistent with the findings of, Yemane Wolde-Rufael (2004) and Enu (2014), on energy consumption and economic growth using regression estimation, and Yilmaz and Ozel (2014) in Turkey on their study on economic growth and energy consumption in developing economies, these studies found a positive and significant relationship between the economic growth and energy consumption in the long run. However, the elasticity coefficient estimated revealed that electricity production has a negative and significant impact on GDP growth rate. It came up that in the short run, a unit increase in the electricity production will lead to -1.0309 decline in the GDP growth rate in Ghana, according to the data. This indicates that, in the short run, there is diseconomies of scale, output increases with cost, however, this increase in power generation is not directed to the productive and economically viable industries; mostly located in the urban communities but rather rural communities (Ghana Rural Electrification Project) where the power is mostly used for domestic purposes, mostly indoors lighting and electrical gadgets. This phenomenon, could only be revered in the long run when the cottage industries begin to use modern technology which requires energy supply to increase their output and have a positive and significant impact on the economy in general and this could take years to realize, due to over politicization of economic dynamics in the country; example power could be supplied to a small cottage at very high cost because the community has threatened government not to vote in the next general elections unless there is light in their " rooms"; the No Light No Vote (NLNV) syndrome.

The elasticity coefficient estimated in the model for electricity use throws more light on earlier analysis on the short run electricity production. It was revealed that in the long run, an increase in electricity consumption reduces GDP per capita by -0.007125, though this relationship not statistically significant at 5 percent significant level, this confirms Ghana Center for Policy Analysis (CEPA) report 2007 on the energy crisis and economic growth, that there is a lot of wasteful use of power, and that there must be a consistent effort to make the power available to the productive sectors of the economy.

The Error Correction Term, represents the speed of adjustment to restore equilibrium in the dynamic model, following a disturbance in the short-run dynamics (Eshun et al, 2014). The estimated coefficient of the ECM which equals -0.796939 suggests a relatively faster speed of adjustment back to the long-run equilibrium. The coefficient is significant at the 5 percent significance level and appropriately signed. According to Verma (2007), a significant error correction term is further proof of the existence of a stable long-term relationship. The result suggests that about 80% of the deviation between the actual and the long-run equilibrium value of Electricity Production and GDP Per capita growth rate is corrected each year. That is approximately more than 80% of the disequilibria from the previous year's shock converge back to the long-run equilibrium in the current year.

It appears that industries and the other productive sectors of the economy like the service sector have not seen the deliberate energy policies to facilitate their growth and hence economic growth in general, but rather power production and supply has been more a political decision than economic over the years.

Granger Causality Test

The existence of a long run relationship between the variables gives way for testing the causality between Electricity production and GDP per capita. Taking into account that the residuals derived from the Granger Causality test may be sensitive to the selection of the lag length, the Schwarz information criterion (SIC) following VAR lag selection was used as shown in the results below:

Table 5. VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1116.919	NA	3.92e+22	60.53618	60.66679	60.58223
1	-1081.691	62.83929*	9.52e+21*	59.11844*	59.64090*	59.30263*
2	-1073.481	13.31320	1.00e+22	59.16116	60.07546	59.48349
3	-1067.739	8.380209	1.23e+22	59.33727	60.64341	59.79774
4	-1060.861	8.922912	1.46e+22	59.45196	61.14996	60.05059

* indicates lag order selected by the criterion

Source: Author's Calculations using data from World Bank WDI Database.

F-Statistics and probability values constructed under the null hypothesis of non-causality are reported in table 6 .Equation (12) and (13) from chapter three are estimated below with F-statistics and Probability values.

Table 6. Pairwise Granger Causality Tests Results

Null Hypothesis:	Obs	F-Statistic	Prob.
ELECTPRO does not Granger Cause GDP/CAP	40	2.60438	0.1151
GDP/CAP does not Granger Cause ELECTPRO		4.99662	0.0315
ELECON does not Granger Cause GDP/CAP	40	4.27340	0.0458
GDP/CAP does not Granger Cause ENECON		4.58890	0.0388
ELECON does not Granger Cause ELECTPRO	40	7.03214	0.0117
ELECTPRO does not Granger Cause ELECON		0.36395	0.5500

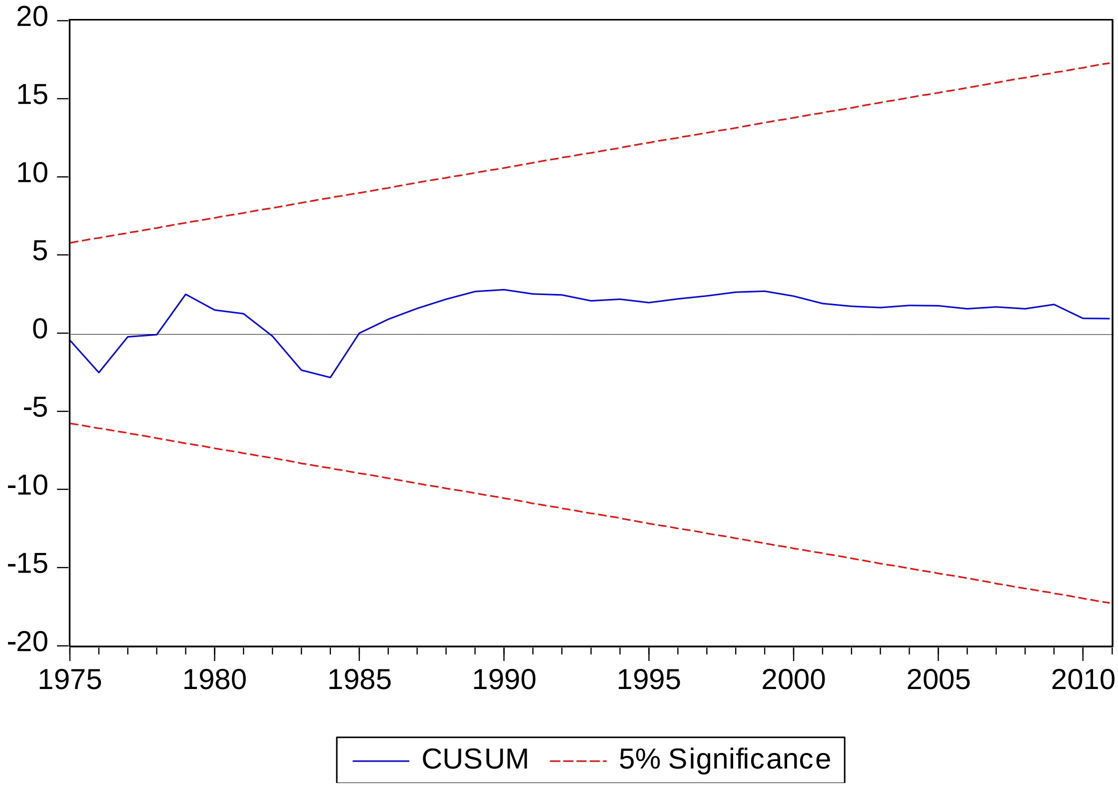
Source: Author's Calculations using data from World Bank WDI Database.

From Table 6, the null hypothesis that GDP Per capita does not Granger Cause Electricity Production rejected given the probability value of 0.0315 < 0.05 implication here is that, there is unidirectional causality relationship, running from GDP Per capita to Electricity production with no feedback effect. This confirms Abaidoo (2014), Paul Adjei Kwakwa (2014), and Adom (2008), on their studies on causal relationship on energy consumption and economic growth in Ghana, also, confirms the Growth-Led-Energy Hypothesis. However, the second causality test supports , Ozel and Yilmaz (2014), who found a bidirectional causal relationship between energy consumption and GDP per capita growth, using data from other developing countries, this relationship was significant in this study, given the p-values of 0.0458 and 0.0388, which is less than 0.05.

The CUSUM Plot Test For Stability Test

Finally, the study also investigates whether the parameters of the estimated GDP Per capita growth and Electricity production regression model were stable enough within the series. This was done by employing cumulative sum (CUSUM) tests proposed by Borensztein, et al. (1998). Unlike the Chow test that requires break point(s) to be specified, the CUSUM tests can be used even if we do not know the structural break point. The null hypothesis that all the coefficients are stable cannot be rejected if the plot of the CUSUM is within the 5% critical bound. However, if the CUSUM Plot crosses any of the diverging lines then, the null hypothesis of parameter stability is rejected at the 5% significant level.

Figure 2: Showing The Test For Stability In The Series (1971-2013).



Source: Author's Calculations using data from World Bank WDI Database.

From figures 2 it could be observed clearly that the CUSUM plots lie within the 5% critical bound thus providing sufficient evidence that the parameters of the model do not suffer from any structural instability over the period of study 1971-2013

CONCLUSION, POLICY IMPLICATIONS AND RECOMMENDATIONS

The paper did a dynamic estimation of the relationship between electricity production and GDP per capita growth rate in Ghana, using the World Development Indicators data on Ghana, spanning from 1971-2013. Study found a positive and significant relationship between electricity production and GDP per capita growth rate in Ghana in the long run; a unit increase in electricity production will lead to 8.94 units in GDP per capita ; However, the short-run dynamics, revealed a negative relationship between electricity production and GDP per capita growth rate in Ghana, and the rate of adjustment back to the long run equilibrium when there is a disturbance in the short-run dynamics, was found to be very fast, that is, The estimated coefficient of the VECM which equals -0.796939 suggests a relatively faster speed of adjustment back to the long-run equilibrium The result suggests that about 80% of the deviation between the actual and the long-run equilibrium value of Electricity Production and GDP Per capita growth rate is corrected each year.

Test for causal relationship was based on Sims (1972) test modeled on Granger's (1969) definition of causality. Result show that there exist a unidirectional causal relationship running from GDP growth to electricity production, confirming the Growth-Led-Energy Hypothesis. However, with GDP Per Capita growth and Electricity Consumption Per Capita, the study found a significant bidirectional causal relationship between the variables.

The study therefore recommends a deliberate energy policy must be made to get the energy supply to the productive sectors of the economy, and distribute power based on economic viability and not political decision, again, power conservation measures must be made to avoid wasteful utilization of power, this will in the long-run help to increase GDP per capita growth rate in Ghana.

LIMITATIONS OF THE STUDY

In order to determine the stationarity and order of integration of the series, a singular process was adopted (Augmented Dickey-Fuller Test) for unit root; however, recent literatures suggest that to ascertain the stationarity and order of integration of a series, more than a singular test process is recommended to help avoid any misleading results. Phillips-Perron tests, Elliot-Rothenberg-Stock Point Optimal, etc are jointly employed for unit roots testing and subsequent determination of stationarity and order of integration in other studies.

REFERENCES

Akaike, H. (1969) "Fitting autoregressive models for prediction" Annals of the Institute of Statistical Mathematics 21, 243 – 247.

Akaike, H. (1973) “Information theory and an extension of the maximum likelihood principle” in 2nd International Symposium on Information Theory by B. N. Petrov and F. Csaki, eds., Akademiai Kiado: Budapest.

Akaike, H. (1979) “A Bayesian extension of the minimum AIC procedure of Autoregressive model fitting” Biometrika 66, 237 – 242.

Akorli, Simons (2005). Electricity Industry Policy Options for Small Economies: The Case of Ghana. A PhD dissertation Proposal

Ayres, R.U., Warr, B. (2009). The Economic Growth Engine. Edward Elgar. Cheltenham, UK

Azali, M., A. Z. Baharumshah, and M.S. Habibullah (2001) “Cointegration test for demand for money in Malaysia: Does exchange rate matter?” in Readings on Malaysia Economy: Issues in Applied Macroeconomics by M. Azali, ed. Imagepac Print: Kuala Lumpur.

Bernanke, B. S. “Alternative Explanations of the Money-Income Correlation.” Carnegie-Rochester Conference Series on Public Policy 25(Autumn 1986), 49-99.

Blanchard, O. J. and D. Quah. “The Dynamic Effects of Aggregate Demand and Supply Disturbances.” American Economic Review 79 (September 1989), 655-73.

Braun, P. A. and S. Mittnik. “Misspecifications in Vector Autoregressions and Their Effects on Impulse Responses and Variance Decompositions.” Journal of Econometrics 59 (October 1993), 319-41.

Caines, P.E., C. W. Keng, and S. P. Sethi. “Causality Analysis and Multivariate Autoregressive Modelling with an Application to Supermarket Sales Analysis.” Journal of Economic Dynamic and Control 3 (August 1981), 267-98.

Cheng, B.S. (1995). An Investigation of Cointegration and Causality between Energy Consumption and Economic Growth. Journal of Energy and Development, 21: 73 – 84.

Chontanawat, J., Hunt, L.C., Pierse, R. (2008). Does Energy Consumption Cause Economic Growth? Evidence from a Systematic Study of Over 100 Countries. Journal of Policy Modelling, 30: 209 – 220.

Diskiene, D., Galiniene, B., Marcinskas, A. (2008). A Strategic management model for economic development. Technological and Economic Development of Economy, 14(3): 375 – 387.

Energy Group, Africa Region and World Bank (2013). Energizing economic growth in Ghana: making the power and petroleum sectors rise to the challenge. http://documents.worldbank.org/curated/en/2013/06/18027411/energizing-economic-growth-ghana-making-power-petroleum-sectors-rise-challenge.

Enu, P. (2014). Sectoral Estimation of the Impact of Electricity Consumption on Real Output In Ghana. International Journal of Economics, Commerce and Management, 2(9): 1 – 18.

Enu, P., and Havi, E.D.K. (2014). Influence of Electricity Consumption on Economic Growth In Ghana: An Econometric Approach. International Journal of Economics, Commerce and Management, 2(9): 1 – 20.

Erol, U., and Yu, E.S.H. (1987). Time Series Analysis of the Causal Relationships between US Energy and Employment. Resource Energy, 9: 75 – 89.

Ferguson, R., Wilkinson, W., and Hill, R. (2000). Electricity Use and Economic Development. Energy Policy, 28: 923 – 934.

Filiz, O., Omer, O., and Huseyin Serdar, K., (2012). Energy Production and Economic Growth: Empirical Evidence from Turkey. Applied Econometrics and International Development, 12(2); 79 – 88.

Gelo, T. (2009). Causality between Economic Growth and Energy Consumption in Croatia. Journal of Economics and Business, Proceedings of Rijeka Faculty of Economics, 27(2): 327 – 348.

Georgescu-Roegen, N. (1971). The Entropy Law and the Economic Process. Harvard University Press. Cambridge Mass.

Ghali, K., El-Sakk, M.I. (2004). Energy Use and Output Growth in Canada: Multivariate Cointegration Analysis. Energy economics, 26: 225 – 238.

Ghosh S. (2002). Electricity consumption and economic growth in India. Energy policy, 30: 125 – 129.

Grossman, G.M., and Helpman, E. (1990). Trade, Innovation and Growth. American Economic Review, 110(2): 86 – 91.

Grossman, G.M., And Helpman, E. (1991). Innovation and Growth in the Global Economy, Cambridge, Mass: The MIT Press.

Guerrerio, J. (2011). Renewable Energy and its Effect on Economic Growth.

Gujarati, D.N., Porter, C., and Gunasekar, S. (2013). Basic Econometrics (5th ed.). Tata McGraw-Hill Education Pvt Ltd.

Holmes, T.J., and Schmitz Jr, J.A. (2001). A Gain from Trade: Unproductive To Productive Entrepreneurship. Journal of Monetary Economics, 47: 417 – 446.

Jumbe, C.B.L. (2004). Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi. Energy Economics, 26: 61 – 68.

Kraft, J., and Kraft, A. (1978). On The Relationship between Energy and GNP. Journal of Energy and Development, 3: 401 – 403.

Lucas, R.E. Jr. (1988). On The Mechanics of Economic Development. Journal of Monetary Economics, 22: 2 – 42.

Mendenhall, W., and Sincich, T. (1989). A Second Course In Business Statistics: Regression Analysis. (3rded.). London: Dellen Publishing Company/Collier Macmillan Publishers

Paul Adjei Kwakwa(2014), Energy-Growth Nexus And Energy Demand In Ghana: A Review Of Empirical Studies ,Applied Research Journal , 28 – 38

Paul Adjei Kwakwa(2012), Disaggregated Energy Consumption and Economic Growth in Ghana, International Journal of Energy Economics and Policy, 34-40

Volta River Authority (1985). Ghana Generation Planning Study, Acres International Limited.

Volta River Authority (1971). Ghana Power Study, Engineering and Economic Evaluations of Alternative Means of Meeting VRA Electricity Demands to 1985, Kaiser Engineers, August.

Yılmaz Bayar et al, (2014), E Journal of Knowledge Management, Economics and Information Technology electricity Consumption and Economic Growth in Emerging Economies.

