KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

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AN INVESTIGATION INTO THE CAUSALITY BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN GHANA

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DECLARATION

I hereby declare that this thesis is my own original work towards the award of master of science in Economics and that, to the best of my knowledge, it contains no material published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been in my work.

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DEDICATION

This work is dedicated to my father, Michael K. Cromwell and Mother; Nancy G. Adams for their sacrifices and support during the period of study, my siblings who sacrificed their financial resources to help finance this programme of study and the entire Cromwell family. May the good Lord richly bless them all.

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ABSTRACT

Knowledge of the direction of the causality between electricity consumption and economic growth is of primary importance if appropriate energy policies and energy conservation measures are to be devised. This study investigates into the long-run relationship between electricity consumption and economic growth as well as the direction of causality between these two variables in Ghana from 1971 to 2013. The study employed the Autoregressive Distributed Lag Model (ARDL) to test for cointegration between the variables and the Granger Causality test was used to determine the direction of the causality between electricity consumption and economic growth. The results from the ARDL showed that there is long-run relationship between electricity consumption and economic growth. Whiles that of the Granger Causality test showed that there exists a unidirectional long-run Granger causality running from economic growth to electricity consumption. These empirical findings imply that electricity conservation policies through both rationalizing the electricity supply efficiency improvement to avoid the wastage of electricity and managing demand side to reduce the electricity consumption without affecting the end-user benefits could be initiated without adverse effect on economic growth. The findings on the long-run relationship indicate that a sufficiently large supply of electricity can ensure that a higher level of economic growth.

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ABBREVIATION

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMSQ	Cumulative Sum of Recursive Residuals of squares
ECG	Electricity Company of Ghana
ECM	Error Correction Model
GDP	Gross Domestic Products
GRIDCo.	Ghana Grid Company
GWh	GigaWatts hour
IEC	Industrial Electricity Consumption
K	Capital
L	Labour
LRR	Long-Run Relationship
MW	MegaWatts
NEDCo	Northern Electricity Department Company
OLS	Ordinary Least Squares
REC	Residential Electricity Consumption
RESET	Regression Equation specification Error Test
SRR	Short-Run Relationship

TFP	Total Force Production
VAR	Vector Autoregression model
VECM	Vector Error correction model
VRA	Volta River Authority

CHAPTER 1

INTRODUCTION

1.1 Background to the Study

According to the augmented neoclassical growth theory, the utilization of energy in an economy has a direct implicit connection with economic growth. The connection is based on the premise that energy can be relied upon as an input substitute or complement 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). Electricity consumption as a form of energy plays a vital role in economic development of countries and has become a focus of many papers involved in the energy economics literature.

The economy of Ghana is highly dependent on electricity, particularly hydroelectricity. As the economy continues to undergo transformation, so has the need for electricity increased. Because, electricity consumption has a direct interrelation with real per capita GDP, it is an intrinsic factor for socio-economic development: increased worker productivity, entrepreneurial activity and higher standards of living.

The total installed and effective capacity of electricity generation in Ghana as at December 2013 stood at 3,081 and 2,631 megawatts (MW) respectively. The majority of this supply, which makes up about 53% of this generation capacity, comes from hydro-based sources which include Akosombo, Bui and Kpong hydro dams. These hydroelectric plants convert water trapped in a dam into electrical energy by using the gravitational force of flowing water to turn a turbine coupled to a generator. The remaining 47% of Ghana's energy supply comes from thermal based plants which function by converting energy stored in fossil fuels such as oil and natural gas into electrical energy.

Figure 1.1 below shows the trend in Electricity consumption per capita and GDP per capita from 1971 to 2013.The figure shows that whiles electricity consumption per capita decreased by 27% from 1980 to 1983, real GDP per capita also decreased by 8% in the same period. From 1984 to 1986, electricity consumption per capita increased by 66.53% whiles real GDP per capita increased by 2%.Also from 20072012, whiles electricity consumption increases by 3.1%, GDP per capita also increases by 5.6%. Thus a positive correlation between electricity consumption per capita and GDP per capita. Albeit this correlation however, the direction of causality between the parameters is not clearly established. It is therefore imperative to determine the causal relationship between real GDP per capita and electricity consumption per capita since any policy aimed towards the electricity should be based on the empirical causal relationship.

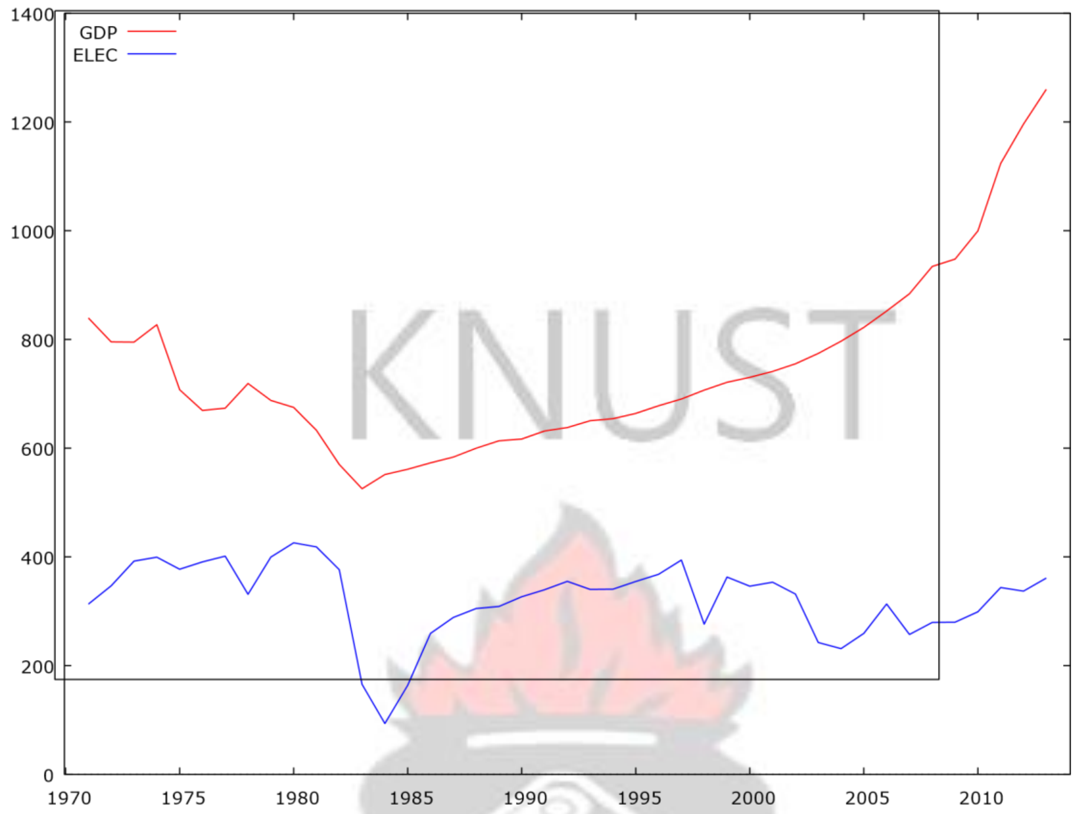


Figure 1.1: Trend in Electricity Consumption and real GDP per capita.

1.2 Problem Statement

Energy is important for sustainable development (Ackah and Adu, 2014). This means that, the causal relation between energy and economic development has consequences on policy making and energy investments. However, the causal direction between energy consumption and economic development is not conclusive. According to a literature survey by Ozturk (2011), there are four main directional hypothesis between energy consumption and economic growth. These are: the 'growth hypothesis', which implies energy consumption Granger causes Economic Development. The second is the 'neutral hypothesis' which posits that there is no relation between energy consumption and economic development. The third is the 'conservation hypothesis' which indicates a direction from economic growth to energy consumption. The final is the 'feedback hypothesis' which implies a bidirectional relation between economic growth and energy consumption. The inconclusive nature of the direction between these parameters and fact that most of these studies are carried out in developed countries presents a literature gap for further research.

Haven't said this, Ghana is currently experiencing load shedding which is due to the inability of the power producers to meet the increased demand of consumers. According to Energy Commission (2014) unmet demand in 2013 was between 1,700-2,480 GWh.

Due to the current power crisis and load shedding exercise, many have advocated for electricity conservation as a part solution to the problem. Energy conservation policies will be detrimental to economic growth if electricity consumption causes economic growth. In other words, if energy consumption is vital for economic growth, conserving energy implies reducing energy consumption and this will cause reduction in growth. According to Goash (2002), this reduction in growth will exacerbate the poverty situation in the country as he asserted that policies that reduce economic growth may reduce job creation and societal welfare.

However, if the direction of causality is from consumption to growth, it implies that Ghana's growth is not so heavily dependent on energy and as a result advocating for energy (electricity) conservation and consequently conserving less energy will have little impact on Ghana's economic growth (Eggoh *et al.*, 2011).

This research therefore aims to find the causality existing between growth and consumption.

1.3 Objective of the study

The study aims to investigate electricity demand management in Ghana. To achieve this objective, the following specific objectives was pursued.

i. To investigate the presence of a long run relationship between electricity consumption and economic growth in Ghana. ii. To estimate the long run and short run relationship between electricity consumption and economic growth in Ghana.

iii. To determine the causal relation between growth and consumption

1.4 Research Questions

The study seeks to answer the following research questions:

i. Does a long run relationship exist between growth and consumption?

ii. What is the nature of the long and short run relationship between electricity consumption and economic growth in Ghana?

iii. Does electricity consumption granger causes economic growth or does economic growth unidirectional granger cause electricity consumption in Ghana?

1.5 Significance of the Study

The aim of this research is to ascertain the causal relationship between economic growth and electricity consumption as well as the elasticity between these variables.

The findings of this study will first and foremost be relevant for policy decisions making for Energy planners and the Government as it will determine if energy conservation policies in Ghana will have detrimental effect on the country's growth or not. Elasticity result will also determine the extent of these detrimental effects in the country.

Several attempts to investigate the causality between energy consumption and growth in Ghana have produced sundry results (see Dramani *et al.,* 2012; Akinlo, 2008; Twerefo *et al.,* 2008, Wolde-Rufael, 2006 and Lee, 2005). This study differs from other studies in that it employs production function approach and controls for other growth variables.

Finally, this study will contribute to the body of literature on the causality between electricity consumption and economic growth in Ghana as it seeks to estimate the causality between energy consumption and electricity consumption using the production function approach by adding labour, capital, and electricity consumption into production function.

1.6 Scope of the Study

Although there are other factors responsible for causing changes in economic growth and electricity consumption, this study shall be limited to only the causality between these two variables. The study is also limited to the situation of Ghana over the time period for which data is available.

1.7 Organization of the study

The thesis is divided into 5 main chapters. The remaining chapters are organized as follows; Chapter two reviews existing literature related to the topic of study. Chapter 3 handles the methodological approach used in the study. Chapter four presents and analyses the results and Chapter five summarizes the main findings of the study and goes on to conclude with some policy recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews both theoretical and empirical literature related to the causal relation between electricity consumption and economic growth. Section 2.2 reviews literature on the various theories relating to the role energy (electricity) plays in economic growth. Section 2.3 reviews various estimation methods; section 2.4 reviews the empirical findings and section 2.5 reviews literature on the long and short run demand for electricity.

2.2 Economic Growth: Role of Energy

Because energy plays a vital role in productivity, it bears major impact on economic growth. According to the neo-classical economic theory of production, output is directly obtained from labour input, thus the economy is a closed system. Subsequently economic growth results from elevated levels of labour or quality of
input.

Mainstream economics since accepting the idea of primary and intermediate factors of production (Stern, 1999) define the former as inputs existing prior to production not necessarily used but subjected under consideration before production begins (though they may be degraded and included in the production process), and the later as those formed in the production line and exhausted during production. Primary factors of production are capital, labour and land. Intermediate factors of production include fuel and materials. Energy is therefore seen as an intermediate input that bears an indirect role in production. The quantity of energy though determined by biophysical and economic constraints is often endogenously given (Stern and Cleveland, 2004). The first to advocate the importance of energy in the economic system was Georgescu and Roegen (1971). They argued a careful analysis of the role of energy in economic growth be done. Following the 1973-74 oil crisis, more economist, including Tintner *et al.*, 1974: Berndt and Wood, 1979) begun to investigate, formulating energydependent production variations that included materials being indigenous labour. Several criticisms to the neoclassical approach are generally invoked, especially in the field of ecological economics (Georgescu and Roegen 1971, Hannon, 1973 and Berndt, E. 1978). The concept of strong sustainability implies that a number of services provided by energy and natural capital cannot, even in principle, be replaced by man-made capital or human labor (Hartwick, 1978). Therefore, energy should be regarded as an essential input to economic production. In contrast to a closed perpetual motion system, the economy should be described as a large materialsprocessing chain (Ayres, 2008), powered by two growth engines (or feedback cycles): the continuing decline of the real price paid for physical resources, specially energy and power delivered to the point of use (resource use growth engine) and the rise in economies of scale, standardization and "learning by- doing" (scale-cum-learning growth engine or Salter cycle). In this perspective, energy emerges as much a driver as a limiting factor of economic development.

The traditional theory of income allocation, which attributes a very small share of factor payments to physical resources (especially energy), is also challenged for being derived from over-simplifying assumptions of a single sector model (Mankiw, 2002). Viewing the economy as multi-sector production chain, where downstream valueadded stages act as productivity multipliers, allows a factor receiving a small share of national income to contribute a much larger share of aggregate production, i.e. to be much more productive (Ayres and Warr, 2002).

The neoclassical perspective is also criticized for failing to ground economic activity in the physical limits imposed by the laws of thermodynamics (Ockwell, 2008). Energy conservation and higher entropy will constrain the limits to which energy and materials can be reutilized. Among other factors affecting the link between energy and growth are the various mechanisms through which energy use and efficiency can affect TFP (Berndt, 1990). Warr and Ayres (2006) argue that energy conversion efficiency can be used as a quantitative measure for the state of technology, either by function or in the aggregate for the whole economy.

2.3 Estimation Methods of Energy Consumption and Economic Growth Causality

According to Guttormsen (2004), empirical studies on causality between energy consumption and economic growth are divided into three; the first, second, and third generation studies. The former which employed the traditional Vector Autoregressive Models (Sims, 1972) causality test, assumed a stationary series. Subesequantly, the second generation studies proposed. As a result the second generation of studies employed cointegration (Johansen and Juselius, 1990) in accessing the energy-growth causal relationship: according to Engle and Granger (1987), sets of quantities were analyzed for cointegration and to estimate an error correction model. The likelihood of two or more vectors of cointegration rendered this model less than ideal. The final approach therefore, allowed for more than a single vector of cointegration. This method factors limitations of cointegration relationship between vectors and investigations into information on short-run adjustments. However, it has two main set-backs: one, the variables should be integrated of order one; and two, a causality test is only possible after the variables have been cointegrated. A fourth generation test employs the Toda and Yomamoto Granger Causality test, founded on the Autoregressive distributed lag model, where no restrictions are imposed on variables. Therefore causality test is possible in any order of integration of the variables: even when they are not cointegrated.

2.4 Information on Electricity Consumption and Economic growth derived from experiment

The review of empirical literature on causality between energy consumption and economic growth has revealed that there are four main hypotheses. These are Growth, conservation, feedback and neutrality hypotheses. Growth hypothesis exist when the causal relationship between causality and growth is a unidirectional one: energy conservation will negatively impact growth. Conservation hypothesis occurs when there is a unidirectional causality from growth to energy, where growth affects energy consumption. On the other hand feedback hypothesis exists when there is a bidirectional causality between energy and growth. This occurs when growth affects consumption and vice versa. Finally when there is no causality between energy consumption and economic growth, this is referred to as the neutrality hypothesis.

The pioneer work by Kraft and Kraft (1978) in USA where a unidirectional causal relation was identified between energy and growth, has generated extensive works on the relationship between energy and growth. According to a research conducted in 1980 by Akarca and Long there existed no causality between the energy and growth, although the period was much shorter than that of Kraft- Kraft. In support of their conclusion, Akarca and Long argued that Kraft- Kraft's study might suffer from temporal time period instability.

Several research have since been conducted on the subject, with some studies confirming or contradicting Kraft-Kraft's conclusion. Stern (1999) conducted a multivariate cointegration analysis of the role of energy in the US macro economy. He established that causal relation between bivariate models is unadvisable because substitution effect of energy with other parametes is not considered; he found no relationship between USA's EC and GDP with a multivariate cointegration model. According to Glasure and Lee (1998), the relationship between energy and growth for South Korea and Singapore is bidirectional. Analysis of some Caribbean states by Francis *et al*. (2007), revealed bidirectional Granger causality for Tobago, Trinidad, Jamaica and Haiti from 1971 to 2002, in the short run. In the long run, while no relationship was discovered for Jamaica and Haiti, a feedback was discovered for Tobago and Trinidad.

Bartleet and Gounder (2010) investigated causality between economic growth and energy consumption in New Zealand from 1960 to 2004 using two (2) multivariate models. First, they construct a demand model with GDP, energy prices and energy consumption. Then, they construct a production function with labour, capital, energy consumption and employment. The long run estimation of the demand model indicates a cointegration relationship GDP, energy prices and energy consumption.
The short run analysis suggests that GDP Granger causes energy consumption.

Asafu-Adjaye (2000) also used a multivariate framework to examine the causality between energy utilization, energy growth for Thailand, Phillipines, Indonesia and India employing cointegration and error correction procedures. The finding revealed a unidirectional Granger causal relationship from energy to economic growth for Indonesia and India, 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.

The causality literature on energy consumption and energy growth in Africa has also been varied with mixed results. Omisakin (2008) investigated the causalit for Nigeria by employing aggregate and disaggregate energy data for the period 1970 to 2005. Utilizing the non-causality approach and the bound testing approach to cointegration which was based on the Autoregressive Distributed Lag (ARDL). The test of cointegration revealed that there is long run relationship between total energy consumption and economic growth and also between oil consumption and economic growth. The study however revealed that there is no long run relationship between gas consumption and economic growth and also between electricity consumption and economic growth. The study revealed a unidirectional causation from total energy consumption to economic growth. Based on disaggregate data, the study observed a unidirectional causation from oil consumption and gas consumption to economic growth while with respect to electricity consumption, no causality was observed between electricity consumption and economic growth.

According to Kwakwa (2014), research into causality relations between economic growth and energy consumption only begun in the year 2000 for Ghana. According to Wolde-Rufael (2006) observations of 17 African countries, a unidirectional causality was observed running from growth to electricity Zimbabwe, Zambia, Senegal, Nigeria, Ghana and Cameroon, whiles the opposite was for six other countries and no causality for the rest. In 2009, Akinlo discovered a bidirectional relationship between energy consumption and economic growth for Senegal, Gambia, and Ghana, vice versa for Zimbabwe and Sudan, and none for Cameroon and Cote D'Ivoire.

Ackah (2015) examined the impact of income, price, education and productivity on renewable and non-renewable energy in selected oil producing Africa countries. Further, the experiment is to test for the causal direction between energy and growth in a multivariate function that includes variables such as TFP, education, and income. Depending on the order of integration, VECM and VAR models are used to test for the causal relation between energy and growth. The causality test suggests a long-run unidirectional causality from non-renewable energy to growth in Ghana and a bidirectional relation in Algeria and Nigeria. This indicates the importance of nonrenewable energy forms to economic growth in these countries and therefore any form of non-renewable energy conservation without appropriate alternatives can hurt growth. The study finds no relation between non-renewable energy and growth in South Africa in the long –run. The test suggests a feedback relation between renewable and growth in Nigeria and a unidirectional causality from renewable to growth in Ghana and Algeria in the long-run. There is a short-run causality from renewable energy to growth in South Africa.

Bildrici (2013) investigated the relationship between electricity consumption and economic growth by using Autoregressive Distributed Lag (ARDL) bounds testing approach and vector error-correction models (VECM) in Cameroon, Cote D'Ivoire, Congo, Ethiopia, Gabon, Ghana, Guatemala, Kenya, Senegal, Togo and Zambia for period 1970-2010. The ARDL results show that there is cointegration relation between electricity consumption and economic growth in ten of the eleven countries. The results reveal that income elasticities of electricity consumption is luxury good for Gabon and Guetemela, necessity good or Engel's good for Senegal and inferior good for Zambia. The causality analysis reports that growth hypothesis exists in Cameron, Congo Rep., Ethiopia, Kenya and Mozambique and the conservation hypothesis in Senegal and Zambia. For Gabon, Ghana and Guatemala, there exists the bidirectional causality between economic growth and electricity consumption.

Adom (2011) researched into the electricity-economic growth nexus in Ghana. The author used data spanning from 1971 to 2008. The Toda and Yomamoto Granger Causality test was employed in investigating the causal relationship between energy and growth. The results showed a unidirectional causality running from growth to consumption, in support of the Growth-led-Energy Hypothesis.

Twerefo *et al*.(2008) also investigated energy consumption (electricity and petroleum) and economic growth nexus in Ghana .The authors employed annual data for the period 1975 - 2006 and the Vector Autoregression model (VAR).The results of the study revealed that causality runs from economic growth to energy (electricity and petroleum) consumption.

Dramani *et al*. (2012) examined 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 pattern. The study revealed that the series 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. The causality test indicates that, there is a unidirectional Granger causality running from economic growth to electricity consumption.

Kwakwa (2012) used the Augmented Dickey Fuller, the Johansen test and the Granger causality test for a similar analysis and found that all variables were integrations of the order one; whiles the later revealed a unidirectional causality from growth to consumption, a feedback relationship between manufacturing and electricity consumption and a unidirectional causality from agriculture to electricity consumption both in the short and long run.

2.5 Short-run vs. long-run demand for electricity.

Electricity does not yield utility by itself, but rather is desired as an input into other processes (or activities) that do yield utility. The processes all utilize a capital stock of some durability (lamps, stoves, water heaters, etc), and electricity provides the energy input. The demand for electricity is thus a derived demand, derived from the demand for the output of the processes in question. However, since durable goods are involved, we must from the outset distinguish between a short-run demand for electricity and a long-run demand. The short run is defined by the condition that the electricity-consuming capital stock is fixed, while the long run takes the capital stock as variable. In essence, therefore, the short-run demand for electricity can be seen as arising from the choice of a short-run utilization rate of the existing capital stock, while the long-run demand is tantamount to the demand for the capital stock itself

(Taylor, 1975).

CHAPTER 3

3.0 METHODOLOGY

3.1 Introduction

The chapter consists of four subsections. Section 3.2 focuses on the specification of the model used for the study. Section 3.4 looks at the estimation technique with emphasis on the autoregressive distributed lag (ARDL) model which was used to estimate the model specified for the study.

3.2 Model Specification

Empirical studies such as Stern (2000); Wolde-Rufael (2010); Lee and Chiang (2005), Shahbaz *et al*. (2012); Lorde *et al*. (2010) employed the production function framework to examine the causal relationship between energy consumption and economic growth. Following the existing literature, the study makes use of conventional neo-classical production model where energy consumption (electricity), capital and labor are treated as separate production factors as below

Y_t □ (EC_t, K_t, L_t) ……………………………………3.1

where Y_t is the GDP growth per capita, EC_t is electricity consumption per capita, K_t is real capital use per capita, L_t is the employed labor force per capita.

However, electricity consumption is disaggregated into residential and non-residential consumption. Therefore the model is restated as;

Y_t □ (REC_t, IEC_t, K_t, L_t) ………………………...3.2

where Y_t is the real GDP growth per capita, REC_t is residential electricity consumption per capita REC_t is non-residential electricity consumption per capita,

K_t is real capital use per capita, L_t is the employed labor force per capita.

The log linear specification of the aggregate equation is specified as follows:

$$\ln Y_t = \beta_0 + \beta_1 \ln EC_t + \beta_2 \ln K_t + \beta_3 \ln L_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.3$$

Where β_0 is the intercept, β_1, β_2, β_3, are the elasticity of aggregate electricity consumption per capita, real capital use per capita and employed labor force per capita respectively .

The log linear specification of the disaggregate equation is specified as follows

$$\ln Y_t = \beta_0 + \beta_1 \ln REC_t + \beta_2 \ln IEC_t + \beta_3 \ln K_t + \beta_4 \ln L_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.4$$

Where β_0 is the intercept, β_1, β_2, β_3, β_4 are the elasticity of residential electricity consumption per capita , non-residential electricity consumption per capita, real capital use per capita and employed labor force per capita respectively .

3.3 Estimation Methodology

The times series data involves three main sequential steps. These are unit root test, test for cointegration and estimation of the short run elasticities using the error correction method. These procedures are outlined below.

3.3.1 Unit Root test

Empirical analysis of time series data is mostly confronted with the issue of nonstationarity. When variables being used for analysis are non-stationary, it usually leads to spurious regression results. In such a case, the t-statistic, DW statistic as well as the R^2 values are not accurate and invalid for inference. The study therefore conducts unit root tests to determine the order of integration of the relevant variables using the framework of Augmented Dickey Fuller Test.

The ADF test for unit root requires the estimation of equation of the form:

$$\Delta y_t = \alpha + \beta t + \delta y_{t-1} + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

y_t is a vector for the time series variables in a particular regression. With respect to this study it is the variables under consideration. t represents time trend, Δ represents the first difference operator, ε is the error term and k represents the optimal lag length.

The ADF test for unit root tests the null hypothesis of unit root against the alternative that the variable in question is stationary. Thus acceptance of the null hypothesis implies that the series has a unit root and hence non-stationary. Similarly, rejection of the null hypothesis of unit root implies the series is stationary.

3.3.2 Test for Cointegration

The second procedure is to examine the presence of cointegration relationship among the variables. 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).

The study makes use of autoregressive distributed lags (ARDL) approach developed by Pesaran*et al*. (2001) to establish the dynamic long run relationship between interest rate spread and industry and macroeconomic variables. This is because this approach has an advantage of been applied irrespective of whether the variables are I(0) or I(1), unlike other widely used cointegration techniques which requires all of the regressors to be integrated of the same order. The ARDL method avoids the larger number of specification to be made in the standard cointegration test. These include decisions regarding the number of endogenous and exogenous variables (if any) to be included, the treatment of deterministic elements, as well as the optimal of lags to be specified. In order to implement the bounds test procedure for cointegration, the following restricted (conditional) version of the *ARDL* model is estimated to test the long-run relationship between economic growth and and its determinants:

$$\Delta \ln Y_t = \beta_0 + \beta_1 \ln Y_{t-1} + \beta_2 \ln RE_{t-1} + \beta_3 \ln NE_{t-1} + \beta_4 \ln K_{t-1} + \beta_5 \ln L_{t-1} + \sum_{i=1}^{n} \phi_i \Delta \ln Y_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta \ln REC_{t-i}$$

$$+ \sum_{i=1}^{n} \delta_i \Delta \ln IEC_{t-i} + \sum_{i=1}^{n} \theta_i \Delta \ln K_{t-i} + \sum_{i=1}^{n} \omega_i \Delta \ln L_{t-i} + \varepsilon_t \qquad \text{........................3.6}$$

where all variables are as previously defined and Δ is the first difference operator. β_i are the long run multipliers in the *ARDL* model, ϕ, γ, δ, θ and ω denote the short-run dynamics of the model to be estimated based on the error correction framework. β_0 is the constant term and ε_t is white noise error term.

3.3.2.1 Bounds Testing Procedure:

The first step in the *ARDL* bounds testing approach is to estimate equation 3.6 by ordinary least squares (*OLS*) in order to test for the existence of a long-run relationship among the variables by conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e.,

$H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$ as against the alternative

$H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$

The test which normalizes on Y is denoted by $F_Y(Y \mid REC, IEC, K, L)$

Two asymptotic critical values bounds provide a test for cointegration when the independent variables are I(d) (where $0 \leq d \leq 1$): a lower value assuming the regressors are $I(0)$ and an upper value assuming purely $I(1)$ regressors. If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive.

In the second stage of the ARDL bounds approach, once cointegration is established the conditional ARDL(p, q_1, q_2, q_3, q_4), the long-run model for can be estimated as:

$$\ln Y_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \ln Y_{t-i} + \sum_{i=0}^{q_1} \beta_2 \ln REC_{t-i} + \sum_{i=0}^{q_2} \beta_2 \ln IEC_{t-i} + \sum_{i=0}^{q_3} \beta_3 \ln K_{t-i} + \sum_{i=0}^{q_4} \beta_4 \ln L_{t-i} + \varepsilon_t \quad 3.7$$

This involves selecting the orders of the ARDL (p, q_1, q_2, q_3, q_4) model using Akaike Information Criterion.

The third and final step, involves obtaining the short-run dynamic parameters by estimating an error correction model associated with the long-run estimates. This is specified as follows:

$$\Delta \ln Y_t = \square_0 + \sum_{i=1}^{n} \square_i \Delta \ln Y_{t-i} + \sum_{i=1}^{n} \square_i \Delta \ln REC_{t-i} + \sum_{i=1}^{n} \square_i \Delta \ln K_{t-i} + \sum_{i=1}^{n} \square_i \Delta \ln L_{t-i} + \square ECM_{t-i} + \square_t \ldots 3.8$$

□□□, , and□denote the short-run dynamics coefficients of the model's convergence to equilibrium and □is the speed of adjustment to long-run equilibrium following a shock to the system.

3.3.3 VECM Granger Causality

Once it is established that there is an existence of long-run association among the variables it is equally important to measure the short-run coefficients as well as the direction of causality between the variables. The ARDL bounds testing approach tests if the existence or absences of long-run relationship among the variables but it doesn't determine the direction of causality This requires the application of Vector Error Correction Models (VECMs) .In VECM all variables in the system are considered to be endogenous variables, so the number of equations becomes equal to the number of variables which is specified below

$$\Delta \ln Y_t = \square_1 + \sum_{i=1}^{n} \square_{1i} \Delta \ln Y_{t-i} + \sum_{j=1}^{n} \square_{1j} \Delta \ln REC_{t-j} + \sum_{k=1}^{n} \square_{1k} \Delta \ln IEC_{t-k} + \sum_{p=1}^{n} \square_{1p} \Delta \ln K_{t-p} + \sum_{q=1}^{n} \square_{1q} \Delta \ln L_{t-q} + \square_1 ECM_{t-1} + \square_{1t} \ldots 3.9$$

$$\Delta \ln REC_t = \square_2 + \sum_{i=1}^{n} \square_{2i} \Delta \ln REC_{t-i} + \sum_{j=1}^{n} \square_{2j} \Delta \ln Y_{t-j} + \sum_{k=1}^{n} \square_{2k} \Delta \ln IEC_{t-k} + \sum_{p=1}^{n} \square_{2p} \Delta \ln K_{t-p} + \sum_{q=1}^{n} \square_{2q} \Delta \ln L_{t-q} + \square_2 ECM_{t-1} + \square_{2t} \ldots 3.10$$

$$\Delta \ln K_t = \square_3 + \sum_{i=1}^{n} \square_{3i} \Delta \ln K_{t-i} + \sum_{j=1}^{n} \square_{3j} \Delta \ln Y_{t-j} + \sum_{k=1}^{n} \square_{3k} \Delta \ln IEC_{t-k} + \sum_{p=1}^{n} \square_{3p} \Delta \ln REC_{t-p} + \sum_{q=1}^{n} \square_{3q} \Delta \ln L_{t-q} + \square_3 ECM_{t-1} + \square_{3t} \ldots 3.11$$

$$\Delta \ln L_t = \alpha_4 + \sum_{i=1}^{n} \beta_{4i}\Delta\ln L_{t-i} + \sum_{j=1}^{n}\gamma_{4j}\Delta \ln Y_{t-j} + \sum_{k=1}^{n} \delta_{4k}\Delta\ln IEC_{t-k} + \sum_{p=1}^{n} \theta_{4p}\Delta \ln K_{t-p} + \sum_{q=1}^{n} \phi_{4q}\Delta\ln REC_{t-q} + \lambda_4 ECM_{t-1} + \varepsilon_{4t} \quad ..3.12$$

3.4 Data Source

Data on capita stock, labour force, aggregate electricity consumption per capita and real GDP growth per capita was obtained from WDI (2015) whiles data on industrial and residential electricity consumption was obtained from VRA, ECG, NEDCo, and GRIDCo.

3.4.1 Description of Variables

3.4.1.1 Labour Force per capita

Total labour force comprises people who meet the International Labour Organization definition of the economically active population: all people who supply labour for the production of goods and services during a specified period. It includes both the employed and the unemployed. The per capita value was derived by dividing the total labour force by the total population.

3.4.1.2 Electricity consumption per capita

Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants divided by the total population. The unit used in the analysis GigaWatts hour (GWh)

3.4.1.3 Residential Electricity consumption per capita

This is the quantum of electricity in GigaWatts hour (GWh) that was consumed by various appliances in the residential sector. This was divided by the total population to arrive at the per capita values.

3.4.1.4 Industrial electricity consumption per capita

This is the quantum of electricity in Gigawatts (GWh) that was consumed by the industrial sector in Ghana. This was divided by the total population to arrive at the per capita values.

3.4.1.5 Capital stock per capita

Gross fixed capital formation is used as a proxy for capita stock. This comprises improvements in land (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

3.4.1.6 Gross Domestic Product per capita growth (2006 constant prices) This is defined as the annual percentage growth rate of GDP per capita based on constant 2006 GHC. Gross domestic product is the value of final goods and services produced within the boundary of a country. GDP was divided by the total population to arrive at the per capita values. The data are in constant 2006 GHC.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This section presents and discusses the result of the study in line with the objectives. Section 4.1 presents and discusses the order of integration of the variables. Section 4.2 deals with the bounds test to cointegration. Section 4.3 and 4.4 presents and discusses the result of long and short run relationship respectively whiles section 4.5 presents and discusses the result of the Granger causality test.

4.1 Unit root test

The study examined the unit root properties of the variables using the ADF test. The ADF test statistics are reported in Table 4.1.

Table 4.1 Results of the ADF unit root test

	LOG LEVEL		FIRST DIFFERENCE	
Variables	constant	With trend	constant	With trend
lnY	-3.460***	-5.641	-7.828***	-7.710***
lnK	-0.762	-2.647	-5.199***	-5.272***
lnL	-2.149	-2.182	-6.103***	-6.042***
lnEC	-3.756***	-3.719**	-5.489***	-5.438***
lnIEC	-0.993	-3.764**	-5.573***	-6.072***
lnREC	-0.665	-2.101	-5.771***	-5.622***

Note: Asterisks (**), (***) show significant levels at the 5% and 1% significance level respectively
-The critical values are obtained from the MacKinnon (1996) for the ADF test

It is evident from the ADF test with constant that in exception of aggregate electricity consumption per capita and real per capita GDP growth all the other variables are non-stationary in log levels. This is because the null hypothesis of unit root cannot be rejected since the test statistic for those variables is not significant. However, the ADF test with trend indicates that aggregate electricity consumption per capita and industrial electricity consumption per capita are stationary i.e. 1(0).

This result implies that GDP, capital stock, labour force and residential electricity consumption exhibit unit roots, implying that any shock to them is permanent.

The variables were first differenced and the unit root test conducted based on the ADF. The ADF test with constant and with trend shows that all the variables are stationary since the test statistic is significant and therefore the null hypothesis of unit root is rejected.

Since the unit root test has confirmed the absence of *I*(2) variables, the *ARDL* methodology can now be applied.

4.2 Bounds test for cointegration

The steps of ARDL analysis involves testing the existence of a unit root, testing the existence of a long run relationship among the variables(i.e.cointegration) and finally estimating the short and long run dynamics of the model. The selection of appropriate lag length is necessary for ARDL bounds test because the calculation of F-statistic is sensitive to the lag order. The appropriate lag length of 1 is selected based on AIC. According to Lütkepohl (2006), the AIC is superior for small sample.

The results of the bound test procedure for cointegration analysis between economic growth and its determinant are presented in Table 4.2.

Table 4.2. Result of the bound test for cointegration

Critical bounds of the -statistic: intercept and no trend						
K	90 %		95%		99%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
3	2.560	3.428	3.078	4.022	4.270	5.412
Computed F-Statistic			Decision			
$F\ Y\ EC\ K\ L_Y(\mid, \quad ,)$	8.0639***		Cointegrated			
Critical bounds of the -statistic: intercept and no trend						
K	90 %		95%		99%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
4	2.402	3.345	2.85	3.905	3.892	5.173
Computed F-Statistic			Decision			
$F\ Y\ REC\ IEC\ K\ L_Y(\mid \quad , \quad , \quad ,)$	4.7936**		Cointegrated			

Note: **, *** means significant at 5% and 1% respectively. Critical values were obtained from Narayan (2004), Appendix A1-A3, pp.26-28. K is the number of regressors.

The result indicates that for the model involving the aggregate electricity consumption, the F- statistic is above both the 5% and 10% lower and upper critical bounds value. This implies that the hypothesis of null which states that there is the absence cointegration is rejected.

Similarly, the model involving electricity disaggregated into residential and industrial electricity consumption suggests that the F- statistic is above both the 5% and 10% lower and upper critical bounds value. This implies that the null hypothesis of no cointegration can be rejected.

Therefore, the study has revealed that there is the existence of a long run relationship among the variables involving the two models.

4.3 Estimates of the long Run Relationship

The long relationship is estimated using a maximum lag of one given the annual nature of the data and the results presented in Table 4.3. Table 4.3: Results of the estimated Long Run Coefficient

$F\ Y\ EC\ K\ L_Y(\ \|\ ,\ ,\ )$ **ARDL(1,0,0,0) based on AIC**				$F\ Y\ REC\ IEC\ K\ L_Y(\ \|\ ,\ ,\ ,\ )$ **ARDL(1,0,0,0,0) based on AIC**		
Regressors	Coefficient	Standard error	T-ratio	Coefficient	Standard error	T-ratio
Constant	4.1842***	1.3109	3.1919	3.4779 ***	1.0835	2.4631
lnK	0.38425 ***	0.0906	4.2402	0.3410**	0.13845	2.4655
lnL	-0.079376	0.12286	-0.64607	-0.20513 **	0.98065	-2.0896
lnIEC				0.046300***	0.014848	3.1182
lnREC				0.061743	0.17041	.36232
lnEC	0.048062**	0.02409	1.9950			

,* means significant at 5% and 1% respectively.

The result presented in table 4.3 endorses the theoretical underpinning that capital stock has a positive influence on growth. The coefficient of capital in the long run growth equation is positive and significant at 1% in both the aggregate and disaggregated equations. This means that in the long run, increases in capital has the potential of stimulating growth in Ghana. For the aggregate equation, a 1% increase in capital leads to an increase in GDP growth per capita by 0.38% whiles in the disaggregated equation, a 1% increase in capital leads to an increase in GDP growth per capita by 0.34% in the long run, ceteris paribus. The result concurs with the results obtained by Aryeetey and

Fosu (2005) who obtained a positive relationship between capital and real *GDP*, though statistically insignificant.

The result also shows that the coefficient of labor is negative and significant in the long run in the disaggregate model. It was expected that labour force influence economic growth per capita positively but the results obtained contradicts this. Specifically, a 1% decrease (increase) in labour force increases (decreases) economic growth by 0.20%, ceteris paribus in the disaggregated model .The result implies that labour productivity in Ghana is very low which might be due to non-performance of specialized task by the workers or could also result from the type of graduates trained by the educational institutions in Ghana who do not have the required skills required by industry.

Aggregate electricity expenditure per person also positively influences GDP growth per capita and this is significant at the 5% level. Specifically a 1% increase (decrease) in electricity consumption per capita increases (decreases) GDP growth per capita by 0.048%.s

Industrial electricity consumption per capita influence economic growth per capita positively in the long run and it is significant at the 1% level. A 1% increase in per capita industrial consumption leads to 0.046% increase in economic growth per capita. The result implies that industrial electricity consumption is a driver of growth in addition to labour and capital in the long run and therefore suggest the importance of energy productivity in industries that use electricity for multiple purposes.

The coefficient of residential electricity consumption is not significant. Residential electricity consumption is mainly done by households for lighting and heating.

Therefore it is not surprising that residential electricity consumption does not have a significant influence on economic growth in Ghana.

4.4 Short run Relationship

After estimating the long run cointegration relationship among the variables, the study proceeded to estimate the short run relationship among the variables in an ARDL framework. The results of the short run analysis are presented in Table 4.4

Table 4.4: Results of the short run error correction model

$F\ Y\ EC\ K\ L_Y(\|, \quad ,)$ **ARDL(1,0,0,0) based on AIC**				$F\ Y\ REC\ IEC\ K\ L_Y(\|, \quad , \quad ,)$ **ARDL(1,0,0,0,0) based on AIC**		
Regressors	Coefficient	Standard error	T-ratio	Coefficient	Standard error	T-ratio
ΔlnK	0.035682***	0.010375	3.4391	0.046300***	0.014851	3.1176
ΔlnL	-0.073709*	0.11471	-0.64256	-0.27851 *	0.15067	-1.8485
ΔlnIEC				-0.0086108	0.019297	-0.44623
ΔlnREC				0.0083921	0.024480	.34282
ΔlnEC	0.044630**	0.020702	-2.1558			
ECM_{t-1}	-0.92860***	0.16023	-5.7954	-0.13577**	0.060317	-2.2510

*,**,*** means significant at 10%,5% and 1% respectively

As discussed in the methodology, the error correction term shows the speed of adjustment to return to equilibrium in the dynamic model. The *ECM* coefficient shows how fast the variables unite to equilibrium and it must be negatively signed and statistically significant.

From the results, it can be seen that the error correction term is appropriately signed and significant at the 1% and 5% level in the aggregated and disaggregated models respectively. This goes to confirm the existence of long run relationship among the variables once again. The coefficient of ECM in the aggregated model is -0.93 which suggests that 93% of the disequilibrium in the previous year is corrected in the current year. For the disaggregated model the coefficient of the error term is -0.14which implies that only 14% of the disequilibrium in the previous year is corrected in the current year.

The short run results shows that all the variables maintained their signs as the long run results and are all inelastic.

Specifically, capital stock influences economic growth positively and significant at 1% level. An increase in capital stock by 1% increases GDP growth per capita by 0.036% in the short run, ceteris paribus. Which implies that there is little responsiveness of GDP growth per capita to changes in capital stock in the short run than in the long run?

In the short run, aggregate electricity consumption significantly influences GDP growth per capita positively. A 1% increase (decrease) in total electricity consumption leads to an increase (decrease) in GDP growth per capita by 0.045%% ceteris paribus. GDP growth per capita is also less responsive to changes in aggregate electricity in the short run than in the long run.

Total labour force per capita also significantly influences economic growth in the short run and maintains its sign as in the case of the long run.

The result also shows that industrial electricity consumption and residential electricity consumption per capita does not have any significant impact on economic growth in the short run.

4.5 Goodness of fit and Model Diagnostics

The significance of the variables and other diagnostic tests such as normality, functional form, and serial correlation among others are conducted in order to check the estimated ARDL model. The results are presented in Table 4.5

Table 4.5 Result of Goodness of fit and Model Diagnostic

Goodness of fit	$F\ Y\ EC\ K\ L_Y(\|, ,)$	$F\ Y\ REC\ IEC\ K\ L_Y(\|, , ,)$
R-Squared	0.43523	0.96980
R-Bar-Squared	0.37417	0.96572
S.E. of Regression	0.037619	0.037728
F-Statistic	7.1283[0.000]	237.6332(0.000)
Akaike Info. Crit	75.8368	77.1431
Schwarz Bayesian Criterion	71.4926	71.861
Residual Sum of Squares	0.052362	.052665
DW-statistic	1.9334	1.8054
MODEL Diagnostics	**Test statistic**	**Test statistic**
$\chi^2_{Auto(1)}$	0.057202(0.811)	0.30510(0.581)
$\chi^2_{Norm(2)}$	54.5218(0.180)	0.90889(0.340)
$\chi^2_{Reset(1)}$	0.32568(0.568)	0.73115(0.393)
$\chi^2_{White(1)}$	0.41673(0.519)	0.10389(0.747)

The results show that for the aggregate model, 43% of the variation in per capita GDP growth is explained by the regressors whiles 97% of the variation in real GDP is explained by the regressors in the disaggregated model. The F-statistic for both models is also significant at 1% level indicating that the regressors jointly explain the regressand.

The diagnostic test also shows that there is no evidence of autocorrelation and the residuals are normally distributed. The model also passes the RESET test for correct specification of the model and the white test for heteroskedasticity.

4.6 Stability test

Brown *et al.* (1975) suggested the use of cumulative sum of recursive residuals (CUSUM) and the CUSUM of square (CUSUMSQ) to test the stability of the parameters of the model. These two tests are based on the null hypothesis that the coefficient vector is the same in every period and the alternative is simply that it is not (Bahmani-Oskooee, 2002). If the plot of these statistics remains within the critical bound of the 5% significance level, the null hypothesis (i.e. all coefficients in the error correction model are stable) cannot be rejected (Bahmani-Oskooee, 2002).

The plots of both CUSUM and CUSUMSQ for the aggregate equation are shown in Figures 4.6.1 and 4.6.2 respectively whiles that of the disaggregate model are shown in Figures 4.6.3 and 4.6.4 respectively.

Fig 4.6.1 Plot of Cumulative Sum of Recursive Residuals for aggregate model

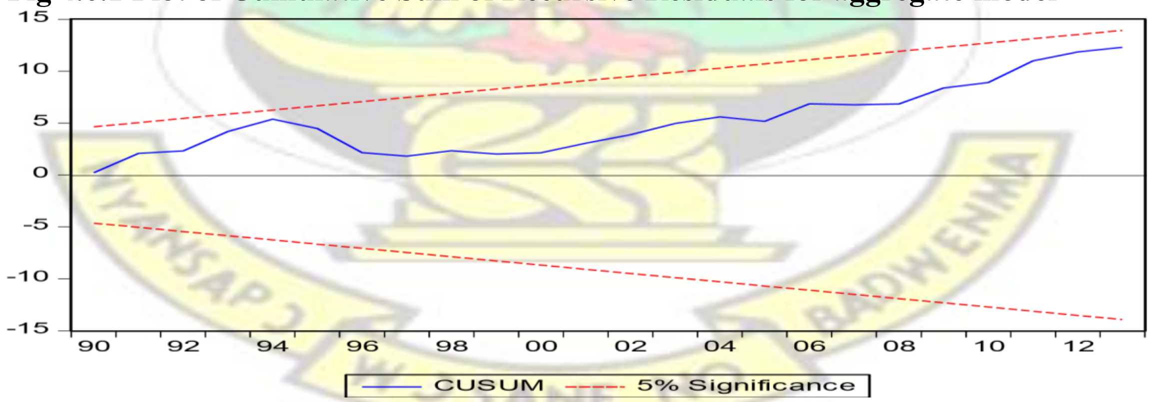


Fig 4.6.2 Plot of Cumulative Sum of Squares of Recursive Residuals for aggregate model

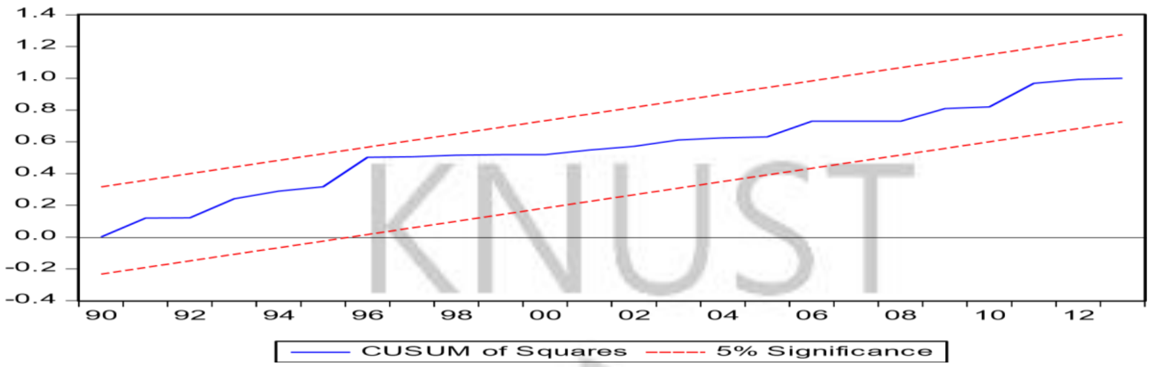


Fig 4.6.3 Plot of Cumulative Sum of Recursive Residuals for disaggregate model

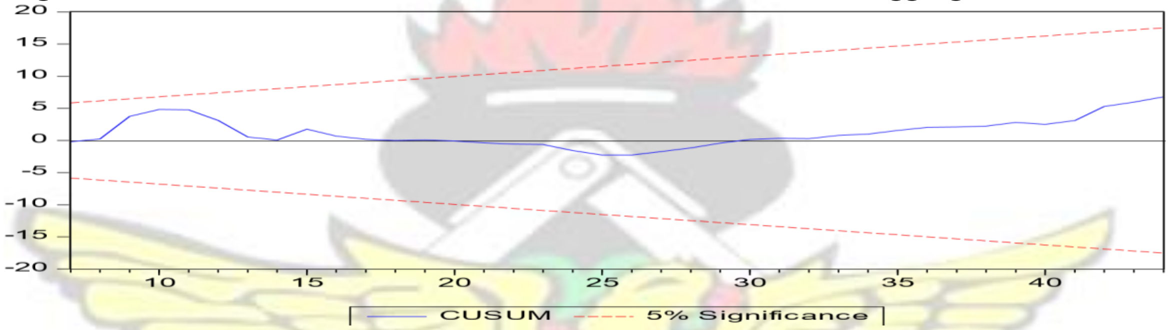
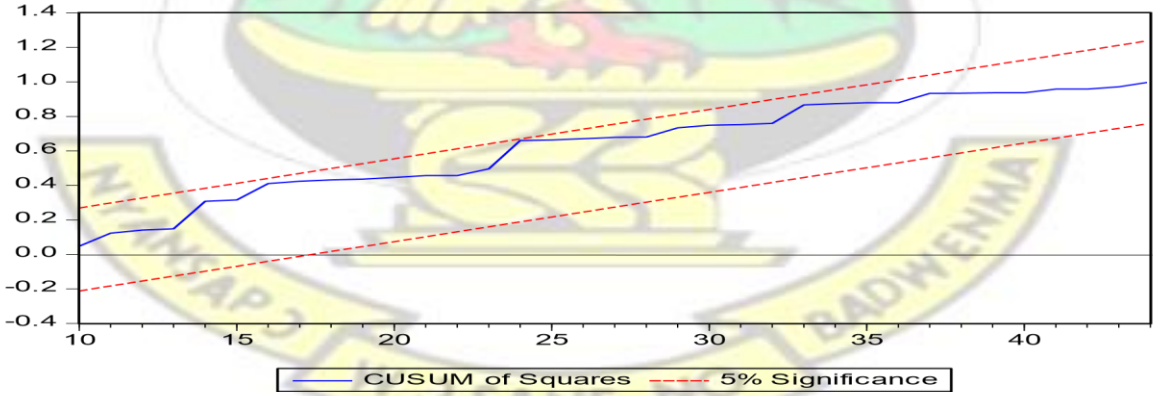


Fig 4.6.4 Plot of Cumulative Sum of Squares of Recursive Residuals for aggregate model



From the figures, it can be seen that both plot of the *CUSUM* and *CUSUMQ* residuals lies within the boundaries in both models. This suggests that the stability of the parameters has remained within its critical bounds of parameter stability. The stability of the two models is therefore confirmed.

4.7 Causality between Electricity Consumption and Economic Growth

The ARDL framework also showed that there exists a long run relationship among the variables but does not indicate the direction of causality. The study therefore examined the direction of causality using the granger causality based on the Vector error correction model (VECM). The causality in the short run is determined by the statistical significance of the partial F-statistics connected with the variables on the right hand side in equations 3.9, 3.10, 3.11 and 3.12 (page 22). On the other hand the causal relation in the long run is revealed by the statistical significance of the t statistic of the respective error correction terms using. The results of the causality test for the aggregate and disaggregate models are shown in Table 4.7.1 and 4.7.2 respectively.

Table 4.7.1: Results of the VECM Granger Causality test of the aggregate model

Dependent Variable	Direction of causality				
	Short run				Long Run
	ΔlnY_{t-1}	$\Delta lnEC_{t-1}$	ΔlnK_{t-1}	ΔlnL_{t-1}	ECM_{t-1}
ΔlnY		0.4412	5.032***	0.200	-1.26
ΔlnK	0.3688	2.554		0.0107	-1.64*
ΔlnL	0.187	0.799	0.0451		1.25
ΔlnEC	4.613**		0.00715	0.698	-3.68***

*, **, *** means significant at 10, 5 and 1% respectively

It can be seen from Table 4.7.1 that per capita GDP growth unidirectional causes aggregate electricity consumption per capita in both the short and long run. This finding agrees with Dramani *et al*. (2012) and Adom (2011) who also revealed that economic growth leads the consumption of electricity in Ghana. This revelation suggests that electricity is demanded like any normal good when income increases.

Also, the share of electricity in the energy mix of Ghana is very minute compared to biomass and petroleum products. For example in 2013, the share of electricity in total final energy consumption was 13.2% whiles that of petroleum and biomass was 47.9% and 38.86% respectively. This suggests that electricity consumption cannot be expected to lead growth given its small share. The implication of the result is that the reduction/ conservation of electricity consumption will not hurt growth.

The result also indicates that in the short run capital stock per capita unidirectional causes economic growth in Ghana.

Table 4.7.2: Results of the VECM Granger Causality test of the disaggregate model

Dependent Variable	Direction of causality					
	Short run					Long Run
	ΔlnY_{t-1}	$\Delta lnIEC_{t-1}$	$\Delta lnREC_{t-1}$	ΔlnK_{t-1}	ΔlnL_{t-1}	ECM_{t-1}
ΔlnY		0.0925	0.4212	0.0172	0.04596	-3.24***
ΔlnK	0.219	5.0194**	2.746		0.0248	1.51
ΔlnL	1.317	3.626*	0.770	0.222		1.50
$\Delta lnIEC$	0.2702		0.707	1.645	2.474	1.74*
$\Delta lnREC$	0.5234	0.00068		0.0123	0.346	1.39

*,**,*** means significant at 10,5and 1% respectively

The result of the disaggregate model indicates that there is a bidirectional causality between economic growth per capita and industrial electricity consumption in the long run.The bidirectional relationship between economic growth and industrial electricity consumption implies that electricity conservation policies directed at the industrial sector will retard economic growth and a drop in economic growth will result further in a decline in the demand for electricity by the industrial sector. Furthermore, in the short run industrial electricity consumption unidirectional granger causes labour forces per capita.

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

The main findings of the study are summarized in this chapter. This is followed by general and policy recommendation based on the main findings.

5.1 Summary of major findings

The study investigated the electricity demand side management in Ghana. Specifically the study dynamic causal relationship shared by electricity consumption (disaggregated into industrial and residential) and economic growth, using the production function approach. The method made use of the time-series data from
1970 to 2013, obtained from VRA, Energy Commission and World Development Indicators. The estimation technique employed in the analysis was the ARDL framework and VECM Granger causality. The Augmented Dicker Fuller (ADF) test was used to discern the order of integration of the variables and the bound test based on ARDL was used to ascertain the existence of a long run relationship among the variables. Since cointegration was established, the study investigated the dynamic causality based on the Vector Error Correction Model (VECM).

With reference to the ADF test, it is evident that with the exception of real GDP per person and aggregate electricity consumption per capita, growth of all other variables exhibited characteristics of non-stationarity in log levels. This is because the null hypothesis of unit root cannot be rejected since the test statistic for those variables are not significant. However, the ADF test with trend indicates that aggregate electricity consumption per capita and industrial electricity consumption per capita are stationary, i.e., 1(0). This means that GDP, capital stock, labour force and residential electricity consumption exhibit unit roots implying that any shock to them is permanent. Also when the variables were first differenced and the unit root test conducted, the ADF test having constants and trends shows that all the variables are stationary because the test statistic is significant and so the null hypothesis of unit root is rejected.

On the other hand, the bond test results and also that for the model involving the aggregate electricity consumption, the F-statistic is above both 5% and 10% lower and upper critical bounds value. This implies that the hypothesis of null which states that there is the above cointegration is rejected.

The study found that at log levels with constant, all the variables were not stationary. The ADF test with constant and trend revealed that with the exception of industrial electricity consumption, the remaining variables only became stationary at first difference.

The cointegration test based on the ARDL framework revealed that the variables have a long run relationship. In the long run, capital stock and aggregate electricity consumption per capita were found to positively influence real GDP growth per capita. On the other hand, the result of the disaggregate model revealed that industrial electricity consumption per capita andcapital stock per capita also had a significant and positive influence on real per capita GDP growth whiles labour force per capita had a significant but negative influence on GDP growth per capita in the long run..

Residential electricity consumption did not have any significant influence on real GDP growth in both the short and long run.

The granger causality test based on the VECM revealed that in all cases, real GDP per capita uniquely causes aggregate electricity consumption in Ghana. The study also revealed a bidirectional causality between industrial electricity consumption per capita and per capita economic growth in Ghana.

5.3 Recommendations

In view of the main findings, following measures are recommended;

- Electricity conservation policy towards the industrial sector should be avoided and alternate energy sources investigated to satisfy increasing energy demand in the industrial sector so as to sustain economic growth.
- Innovation and efficiency in generating and distributing electricity to the industrial sector should be encouraged in order for this sector to be more competitive and to spur the economic growth of Ghana.
- Electricity supply to the residential sector should be reduced. This can be done through higher tariffs in order to make residential electricity consumption efficient

5.2 Conclusion

From the main findings of the study, it can thus be concluded that electricity consumption in Ghana and Economic growth move together in the long run and therefore share a common trend.

Aggregate electricity consumption positively influences economic growth in both short and long run whiles industrial electricity consumption positively influences economic growth only in the long run. Thus, reflexes in electricity supply impact negatively on economic growth.

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