UNIVERSITY OF CAPE COAST

ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN GHANA

BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate Signature:……………………… Date:…………………….

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Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

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ABSTRACT

The study examined the relationship between electricity consumption and economic growth in Ghana using annual data for the period 1971 to 2010 by employing autoregressive distributed lag (ARDL) approach to cointegration. The study found a cointegrating relationship among the variables when real GDP was used as the dependent variable and no cointegrating relationship among the variables when electricity consumption was used as the dependent variable. The bounds test results revealed that electricity consumption exerted a positive and statistically significant effect on economic growth both in the short-run and long-run suggesting that higher electricity consumption is crucial to economic growth in Ghana.

Further, financial development, labour force and capital stocks exerted a positive and statistically significant impact on economic growth both in the short-run and long-run signifying that capital, labour force and financial development are critical in enhancing sustained economic growth and development in Ghana while inflation revealed a negative effect on economic growth as expected and that it is recommended that government consider creating and maintaining macroeconomic stability necessary for energy development and competition while encouraging the stakeholders in the electricity sector to enhance technological and human resource development. The Granger causality test result also revealed a unidirectional causality running from economic growth to electricity consumption indicating that electricity conservation policies are viable options for Ghana since this will not retard growth in the economy.

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DEDICATION

To my sweet mother for her unflinching support, love and inputting into my education.

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LIST OF ACRONYMS

ADF	Augmented Dickey-Fuller Test
AERC	African Economic Research Consortium
AIC	Akaike Information Criterion
ARDL	Auto Regressive Distributed Lag
ASEAN	Association of South East Asian Nations
BIC	Bayesian Information Criterion
BW	Bandwidth
CPI	Consumer Price Index
EC	Electricity Consumption
ECG	Electricity Company of Ghana
ECM	Error Correction Model
ECT	Error Correction Term
FD	Financial Development
GDP	Gross Domestic Product
GNP	Gross National Product
GoG	Government of Ghana
GRIDCo	Ghana Grid Company
GWh	Giga Watts per hour
HP	Hodrick Prescott
IEA	International Energy Agency
IMF	International Monetary Fund

INF	Inflation
ISSER	Institute for Statistical, Social and Economic Research
JAIDS	Journal of Acquired Immune Deficiency Syndrome
KWh	Kilo Watts per hour
MENA	Middle East and North Africa countries
MW	Mega Watts
NED	Northern Electricity Department
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PP	Phillips-Perron
PPP	Public Private Partnership
PURC	Public Utilities Regulatory Commission
R&D	Research and Development
RGDP	Real Gross Domestic Product
RGNP	Real Gross National Product
SBC	Schwartz-Bayesian Criterion
SHEP	Self Help Electrification Projects
SIC	Schwarz Information Criterion
TAPCo	Takoradi Thermal Power Company
TFP	Total Factor Productivity
TICo	Takoradi International company
TPPS	Takoradi Thermal Power Station
UCEM	Unrestricted Error Correction Model

USA	United States of America
VAR	Vector Autoregressive
VEC	Vector Error Correction
VECM	Vector Error Correction Model
VOCs	Volatile Organic Compounds
VRA	Volta River Authority
WDI	World Development Indicator

CHAPTER ONE

INTRODUCTION

Background to the Study

Electricity is a vital ingredient in the socio-economic development of any nation, especially developing nations. Not only is it a critical factor in their development, it is sometimes seen as a measure of the quality and standard of living of a nation. It enables consumers to use daily appliances such as computers, medical devices, telecommunication appliances and transport vehicles that increase the quality of life (Ighodaro, 2010). No wonder Kemp (2005) describes electricity as the life breath of modern society. Without a safe, sustained, reliable and reasonably affordable supply of electricity to meet demand, a country can hardly make progress in its economic and social development.

Examples of electricity's role as a key input into economic activity are myriad. The primary sector of the economy, which includes activities related to extraction of resources from the earth (for example, mining and farming), uses electricity to operate heavy machinery that can make processes faster and more efficient, the secondary sector, which includes activities related to manufacturing and production, uses electricity to power factories, warehouses, and the equipment inside of them. The tertiary sector, which includes service business and retail operations, uses electricity for lighting, heating and cooling, and the operation of productivity tools like computers and printers (Fornelio, 2010).

The experience of developed countries shows that the electricity supply sector played a crucial role in their economic development not only as a key input in their industrial, technological and scientific advancement but also as a key factor in improving the quality of life of their people. Even in poor countries, it is argued that the use of electricity is associated with improving the health and education standards of the poor. At the individual level, increased electricity use is likely to be one of the most important causes of improved welfare of the poor. At the national level, in the era of the digital economy, it is not easy to envisage development without the use of modern energy, particularly electricity (Wolde-Rufael, 2006).

Though the electricity supply industry in Ghana contributes only 10 percent of its energy-supply mix, the industry is a key driver of economic growth and development, powering the country's industrial, commercial and urban development. The industrial, agricultural, mining and services sectors of the Ghanaian economy, which together account for 75 percent of the country's GDP, rely critically on the electricity industry for their survival. The electricity industry accounts for 14.7 percent of total energy share in the industrial sector, and 32.6 percent energy consumption in the formal manufacturing sector. It also contributes 2.8 percent of real GDP and 10.65 percent of industrial GDP. With a customer base of approximately 2 million, it is estimated that 45-47 percent of Ghanaians including 15-17 percent of the rural population have access to grid electricity with a per capita electricity consumption of 358kWh while the average annual growth rate stands at 9.7 percent (Institute for Statistical, Social and Economic Research (ISSER), 2005).

Electricity consumption also depends on the stage of economic growth. For the proponents of this argument, economic growth is a necessary condition to insure better standards of living. They believe that economic growth translates to higher wages and incomes for workers and more employment allowing them to purchase a big ticket item such as automobiles, houses, refrigerators, air-conditions, washing machines, mobiles, cooking utensils etc. which leads to higher electricity demand and hence electricity consumption (Shahbaz and Lean, 2011).

According to Khan and Ahmed (2009), the heightened interest by the major economic powers at gaining a firm foothold on energy rich regions across the globe is an effort to insure their uninterrupted long term supply of energy for a seamless trajectory of economic growth path. Understandably, energy will still remain a major focus in the future and the battle for control will only intensify in the days ahead. Wolde-Rufael (2006) pointed out that the spurt in demand for electricity in emerging economics is closely linked with increases in income.

The relationship between electricity consumption and economic growth has now become an important issue for academic research particularly regarding electricity policies. This is essential because when a nation is heavily dependent on electrical energy, environmental hazards could possibly have a negative impact on economic development. For instance, natural gas, normally used in producing electricity, is a major contributor to CO_2 emission. Coal alone accounts for over 50 percent of all CO_2 emissions. Also, since the Earth Summit of Rio de Janeiro in 1992 and the Kyoto Protocol in 1997, which state that environmental degradation and climate changes are related to fossil energy consumption, some experts suggest a lowering of the world energy use (Eggoh, Rault & Bangaké, 2011).

Therefore, whether the economic development takes precedence over electricity consumption or electricity itself is a stimulus for economic development has motivated curiosity and interest among economists and policy analysts over the past decade to investigate the relationship and direction of causality between electricity consumption and economic variables such as GNP, GDP, income, employment or electricity prices. This is because the direction of causality has significant policy implications (Jumbe, 2004).

If a unidirectional causality running from economic growth to electricity consumption or if there is no causality in either direction, this signifies a less electricity dependent economy such that electricity conservation policies (for example, electricity rationing) would not affect economic growth. However, if the causality runs from electricity consumption to GDP, this signifies an electricity dependent economy such that electricity consumption is a stimulus for GDP growth, implying that shortage of electricity may negatively affect economic growth or may cause poor economic performance (Stern, 1999).

Karanfil (2009) suggested that in exploring the causal links between electricity consumption and economic growth, economists should consider the inclusion of other variables rather than just the bivariate case. According to him, the omission of relevant variable can seriously affect the result of the study. One of the variables, he suggested is the financial development variable such as the stock market, domestic credit to private sector and/or liquid liabilities.

Statement of the Problem

It cannot be denied that electricity is a necessity of daily life. It is pervasive in everything people do, from running their appliances to lighting their homes to fueling their entertainment and communications with the outside world. Electricity is also an indispensable factor for the social and economic development of societies and the usage levels of electricity is an indication of the economic prosperity of nations (ISSER, 2005).

Over the past few decades, the role of electricity consumption in economic growth has attracted significant attention from energy and development experts and has been debated extensively. Even though it is very well known that there is a strong correlation between growth and electricity use, the issue of "causality" that is, whether economic growth leads to increases in electricity consumption or that electricity consumption is the engine of economic growth.- remains still to be answered (Masih & Masih, 1996). Empirical evidence especially time series studies have generally been mixed and inconclusive.

Specific studies on the relationship between electricity consumption and economic growth in sub-Saharan African countries especially Ghana (Adom, 2011; Twerefo, Akoena, Egyir-Tettey & Mawutor, 2008; Akinlo, 2008; Lee, 2005; and Wolde-Rufael, 2006) are very few. Some of these studies have used cross-country regression method. This method is saddled with heterogeneity bias. As such, it fails to address the country-specific effects of electricity consumption on economic growth which may lead to inconsistent and misleading estimates (Akinlo, 2008; Lee, 2005 and Wolde-Rufael, 2006). In addition, some other studies for instance Adom (2011) and Twerefo et al. (2008) using time series employed a bivariate VAR framework, however, bivariate tests suffer from omitted variable problem and this may lead to erroneous causal inferences.

It is against this background that this study seeks to investigate the relationship between electricity consumption and economic growth for Ghana using autoregressive distributed lag (ARDL) approach to cointegration.

Objectives of the Study

The general objective of this study was to investigate the relationship between electricity consumption and economic growth using annual time series dataset for Ghana.

Specifically, the study sought to:

1. Investigate the long-run relationship between electricity consumption and economic growth.
2. Examine the short-run relationship between electricity consumption and economic growth.
3. Explore the nature of causal relationship between electricity consumption and economic growth.

4. To provide policy recommendations

Hypotheses of the Study

The study seeks to test the following hypotheses.

1. H_O: There is no long run relationship between electricity consumption and economic growth.
2. H_O: There is no short run relationship between electricity consumption and economic growth.
3. H_0: There are no causal relationships between electricity consumption and economic growth in Ghana.

Significance of the Study

The research results are relevant to policy makers, development planners, finance experts and researchers. Investigating the electricity-growth nexus can be of principal interest to government and energy planning. It will help stakeholders formulate policies capable of enhancing the development and effectiveness of the energy system.

Again, the results of the study can serve as a guide to constructing appropriate energy sector reforms and in evaluating the effectiveness of these reforms since countries undertaking reforms hope to achieve a more competitive, healthier, efficient and deeper energy system and also the results from these causality tests may provide vital information that would be of help in formulating macro econometric models, effective and efficient energy policy to sustain the economic growth of the country.

Also, there exist few studies using time-series analysis on the electricity consumption-economic growth relationship especially in the case of Ghana. This study adds to the existing literature. In so doing the study addresses some of the methodological issues inherent in the literature.

Scope of the Study

This study investigates the relationship between electricity consumption and economic growth in Ghana using annual time series data set for the period 1971 to 2010. The choice of the data coverage was informed by the fact that it was extremely challenging getting data below 1971 on electricity consumption per capita which is a key variable in the electricity consumption and economic growth relation. The study employed the following variables: Electricity consumption, economic growth, financial development, capital stock, labour force, inflation and dummy variable for economic reform and constitutional regime.

Economic growth is proxied by changes in real gross domestic product (GDP) per capita and electricity consumption per capita is used to proxy electricity consumption. The variables such as capital stock, labour force, financial development and inflation were used to augment the model. Capital stock was proxied by the share of gross fixed capital formation to GDP and financial development is proxied by *M2* money supply as a percentage to GDP. Inflation is also measured by changes in the consumer price index.

The study employs the recently developed Autoregressive Distributed Lag (ARDL) model otherwise known as the bounds testing approach to cointegration developed by Pesaran and Shin (1999) and Pesaran, Shin and Smith (2001).

Organisation of the Study

This study is organized into five chapters. Chapter one, which is the introductory chapter, presents a background to the study, problem statement, objectives of the study, hypotheses, significance and scope of the study as well as organisation of the study. Chapter two presents review of relevant literature, both theoretical and empirical on the relationship between electricity consumption and economic growth.

Chapter three presents the methodological framework and techniques employed in conducting the study. Chapter four examines and discusses the results and main findings with reference to the literature. The final chapter presents the summary, conclusions and recommendations of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

The broad aim of this chapter is to present the review of related literature on the relationship between electricity consumption and economic growth in Ghana. This is aimed at getting supporting theories and empirical evidence for the study. The chapter is organised into three sections. The first section presents an overview of the Ghanaian economy with specific focus on the electricity industry. The second section presents and discusses the theoretical literature on the relationship between energy (electricity) consumption and economic growth and finally, the last section reviews the empirical literature on energy (electricity) consumption and economic growth.

Overview of the Ghanaian Electricity Sector and Economic growth

Electricity is produced and delivered to customers through three different steps; generation, transmission and distribution as demonstrated in Figure 1. First of all, before electricity can be delivered, it needs to be generated. Generation plants consist of one or more generating units, that is rotating turbines, which convert mechanical electricity into electricity. Through generation substations, which connect generation plants to transmission lines, the electricity is transferred to the transmission system in order to be transported over long distances. The transmission system will make it possible to optimize the production of electricity within a country and for power trading between countries. A transmission substation contains transformers to step down voltage to distribution levels and is a kind of connection point between the transmission system and distribution system. The distribution system transfers and divides the electric power to be delivered to customers as electricity (Fornelio, 2010).

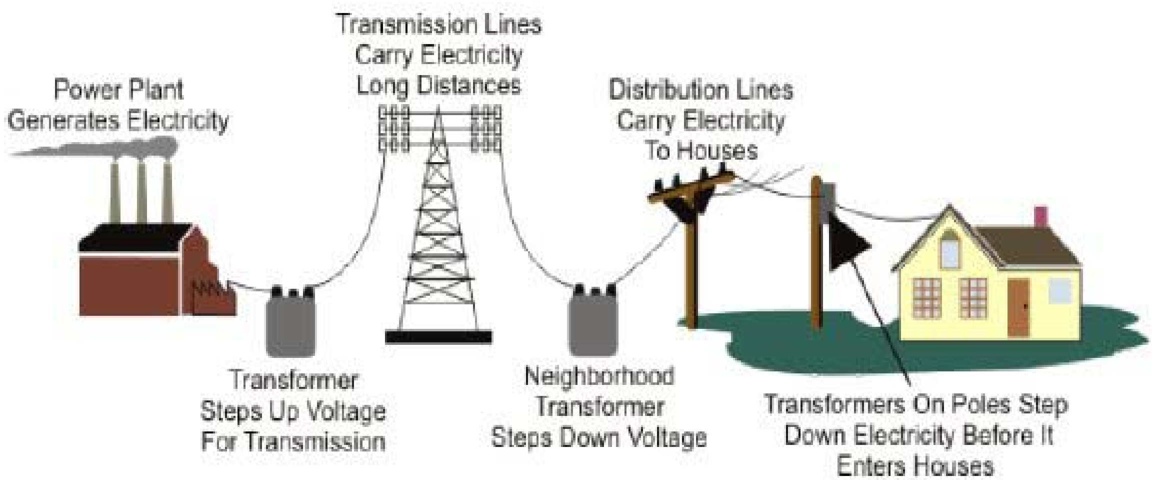

Figure 1: The Electric Power Flow – from Generation to End Customers

Source: Fornelio, 2010

In Ghana, these three-step processes are controlled by three different utility companies. The Volta River Authority (VRA) is a state-owned enterprise that is solely responsible for bulk power generation in the country. Currently VRA operates the Akosombo and Kpong hydro stations which happen to be the major power generation sources in the country. Limited generation is also undertaken by a private company, the Takoradi International Company (TICo), a joint venture ship between VRA and CMS Electricity Inc. of the USA (ISSER, 2003).

Ghana Grid Company (GRIDCo) is also responsible for transmitting power from bulk power plants to distribution lines while the Electricity Company of Ghana (ECG) and the Northern Electricity Department (NED), the latter being a directorate of the VRA are responsible for electric power distribution in the country to the final consumer. The Electricity Company of Ghana delivers power to customers in the southern half of the country comprising Ashanti, Western, Central, Eastern, Volta and Greater Accra Regions while the Northern Electricity Department has responsibility for supplying power to customers in the northern half of the country consisting of the Brong Ahafo, Northern, Upper East and Upper West Regions (Ghana Grid Company Limited, 2010).

The Public Utilities Regulatory Commission (PURC) and the Energy Commission are two government agencies that regulate the utilities for the public good rather than private interests. The PURC is an independent body with primary responsibility for setting the tariffs that utilities charge their customers. The ECG on the other hand is tasked with licensing and regulating the technical operations of the utilities. Both regulatory agencies also ensure fair competition in the power market, enforce standards of performance for the provision of services to customers and protect both customer and utility interests. Electricity policy formulation is the preserve of the Ministry of Electricity while the Electricity

Foundation, a non governmental agency has been very active in promoting electricity efficiency measures (ISSER, 2005).

The electricity sector has experienced significant growth over a decade now. In 1992, electricity and water sector recorded a growth rate of 12.02% which was 5.43% higher than the previous year. The primary reason, as reported in the budget statement and economic policy for 1993, included expansions in the national electricity grid under the rural electrification programme and the expansion and up-grading of some urban electricity distribution networks. In 2000, the sector witnessed a growth rate of 4.5% which was below the 1992 figure. In terms of the sectors relative contribution to total industrial growth in the country, the electricity sector contributed 10.21% of total industrial GDP in 2000. In 2005, the sector witnessed an increase in growth rate of 12.4% which translated into the sectors increased relative contribution to total industrial GDP of 11.9%. However, in 2007, the sector recorded a decrease in growth rate of 17.4% which caused the sector's relative contribution to total industrial GDP to fall to 10.2%. (ISSER, 2007).

The major reason behind the sectors decreased contribution was mainly due to the serious drought that thumped the Ghanaian economy in 2007 which led to plummet in the water level of Akosombo, the foremost power house for the country.

History of Electrical Power Generation in Ghana

The history of electricity production in modern Ghana dates back during the colonial times in 1914 when the electricity supply sponsored by the government was initiated in Sekondi in the Western part of modern Ghana (ISSER, 2005). Since then various reforms and restructuring has taken place. However, it is not the focus of this section of the report to relate the long history and the various transition reforms that took place (thus, pre independence era).

However the historical path of Ghana's electrical power production can be divided into three main phases. a) Before the hydro years: this period refers to the time period before the main hydro plant in Akosombo was built in the 1966. b) The hydro years: refers to the time period from 1966 when the Akosombo hydro plant was completed to the 1980s. c) Thermal complementation years: the 1990s to present when thermal plants were used to supplement the hydro generation (Asare, 2008). This thesis focuses on the post independence era especially since the late 70s to the present time.

Hydro Generation

Currently, Ghana operates two main hydro power plants and two thermal plants. The first and the biggest hydro plant built is the Akosombo hydro plant with an installed capacity of 1020 MW located in the Eastern part of the country in 1966 and the main purpose initially was to supply electric power to the aluminum industry. The building of the Akosombo hydro dam flooded the Volta river basin creating the largest manmade lake in the world which covers approximately 3.6% of Ghana's land area. The power generated from the Akosombo plant serves as the driving force behind Ghana's economic development and also supported neighbouring countries such as Togo and Benin by exporting power to these countries (Suave, Dzokoto & Opare, 2002).

With Ghana's expanding industry and the nature of economic development which caused greater demand for electric power in the 1980s, a second but smaller hydro power plant called the Kpong Hydro plant with an installed capacity of 160 MW was developed on the downstream of the same Volta River to supplement the Akosombo hydro plant. Between 1982 and 1984 occurred one of the most severe droughts in the Volta River Basin in recorded history (ISSER, 2005). This greatly affected the production output of the two hydro electric power plants and led to the search and additional sources of producing electricity other than hydro source.

Thermal Addition

To complement the existing hydro power plants, the Volta River Authority (VRA) in 1997 established the Takoradi Thermal Power Station (TPPS) in the Western region of the country, the first of its kind in Ghana. A 550 MW installed capacity with a joint private partnership as part of the government plans to allow private participation in the electricity generation sector. The Takoradi thermal Power Company consist of two companies all located in the same region. It consists of a 330 MW combined cycle plant called Takoradi Thermal Power Company (TAPCO) with a private partnership with CMS Electricity of USA in a ratio of 10 percent (VRA) to 90 percent. And the second part is the Takoradi international company (TICO), A 220 MW installed gas turbine plants in a ratio of 10 percent (VRA) to 90 percent (Asare, 2008).

Currently, all the thermal power plants are fuelled with light fuel. However with expected natural gas from Nigeria (as Ghana is part of a West African joint project called the West African Gas Pipe line project) high cost of fuel associated with the light fuel is expected to fall as natural gas is relatively cheaper than light fuel. There is also a 30 MW diesel power plant at Tema near the capital in the Greater Accra region of the country. Again a third hydro power plant called the Bui Dam with installed capacity of approximately 400 MW has been developed to complement the existing two hydro plants. Unlike the two other hydro plants, the Bui Dam is a joint venture between the Government of Ghana (GoG) and a Chinese construction company Sino Hydro (Asare, 2008).

Electricity Demand and Supply in Ghana

At present, Ghana’s electricity sector has a customer base of more than 2 million residential and commercial customers and 1,150 industrial customers. In 2009, these customers contributed to a peak power demand of 1,423 MW and a cumulative energy demand of 10,116 GWh (Ghana Grid Company, 2010). Peak demand is the maximum amount of electricity that customers consume instantaneously, while energy demand is the amount of electricity they use over time (thus, the sum of instantaneous demand over time).

Electricity demand in Ghana is divided across 40 load centres, which include cities, clusters of smaller towns and villages, and large industrial sites such as mines. In Ghana, a relatively small number of load centres account for a large fraction of total demand. In fact, Ghana's ten largest load centres together accounted for nearly 68% of peak demand and 72% of energy consumption in 2009. Most of these load centres coincide with urban centres – Accra, Tema and Kumasi alone account for approximately 49% of total national peak demand (ISSER, 2007).

The remaining major load centres are associated with heavy industrial activity. Industrial customers are characterized by very high, consistent power demands. The four largest mines alone accounted for 12.5% of national peak demand, and each mine consumed a significant amount of energy relative to their peak demand. For instance, the load centres at Takoradi and New Obuasi had similar peak demands of 44.7 MW and 53.0 MW while New Obuasi as a mining site had over 50% more annual energy demand than Takoradi (Ghana Grid Company, 2010).

Generally, domestic consumption of electricity has been increasing continuously even though domestic production of electricity in Ghana has been inconsistent largely due to inadequate investment in additional capital and unpredictable nature of the weather. It is important to reiterate here that the balance between electricity demand and supply is an important prerequisite to ensuring a reliable electricity system. Ghana's electricity sector has experienced considerable prolong power shortages over the last decade. For instance in 2000, while electricity demand stood at 7488.9 GWh, electricity supply stood at 7233GWh representing a demand-supply gab of 265.9 GWh. Also in 2001, while domestic electricity stood at 8012.1 GWh representing a 7.1 percent increase, domestic electricity supply stood at 7857 representing an increase of 8.8 percent. This shows a demand – supply gab of 153.1 GWh. However, in 2008, while domestic electricity demand stood at 8066 GWh, domestic production of electricity stood at 8324 GWh representing a demand – supply gab of -257.8 GWh (Adom, 2011).

Important to the analysis of the demand – supply gap is the existence of losses in the form of technical and non- technical losses of power within the electricity sector. Technical losses are largely caused by energy dissipated as heat in the restrictive, conductors and equipment used for transmission, transformation and distribution of power. Non-technical losses on the other hand include pilferage, defective metres and errors in accounting for electricity consumption. In practice, non-technical losses are largely confined to distribution while technical losses are present in generation, transmission and distribution (Adom, 2011).

Generally, losses account for approximately 24% of electricity demand in Ghana which is normally driven by distribution losses (both technical and non-technical). In comparison, losses account for only 6.5% of demand in the United States of America (USA) and 21.21% in Rwanda. Transmission losses in Ghana are about 3.8 compared to an industry rule-of-thumb of 3% (Ghana Grid Company Limited, 2010). These huge losses in Ghana's electricity sector are partially responsible for the current trend of deficit within the electricity sector.

One major step undertaken to curtail losses in the system has been the installation of prepaid metres. It must be said here that, although, this is a good step not much has been achieved in terms of national coverage.

Environment and Energy Policy Issues

Environmental concerns are a prominent part of every industry today and the electric power industry is no exception (ISSER, 2005). Coal and lignite are taken from underground and strip mines. Natural gas wells are drilled to provide fuel to generate electricity. Power plants that use fossil fuels emit pollutants that are subject to emissions regulations. Transmission lines also spread across the state, affecting human and natural environments. These activities are monitored and regulated, but because of the size and scope of the industry, there will always be concern about electric power and its environmental effects (Stern, 2003).

According to Weedy (1987), power plants use various fuels that are linked to problems like acid rain, urban ozone depletion, global warming and waste disposal. Each fuel has its own environmental advantages and disadvantages. Coal, one of the lowest priced fuels, requires considerable treatment of emissions to meet environmental standards and its use triggers concerns about global warming. Natural gas, a more expensive fuel, burns cleaner than coal but can contribute to ozone formation in urban areas. Wind and solar power which require relatively high capital costs produce no direct emissions and have virtually no fuel cost but they can be unsightly or impact wildlife negatively. Nuclear power plants emit no combustion gases but have raised the issue of long-term disposal of spent fuel.

Ghana generates most of its power from hydroelectric facilities, which do not cause emissions of harmful elements into the atmosphere; but their large reservoirs have some impact on the environment by flooding large areas, causing people to move, changing their ecology and causing silt formation (Adom, 2011). He again argued that acid rain, urban ozone depletion, particulate emissions and global warming are the four primary air pollution concerns for the electric power industry. Power plants contribute relatively little to emissions of Volatile Organic Compounds (VOCs), carbon monoxide, nitrous oxide (a greenhouse gas and oxide of nitrogen), or methane (a greenhouse gas) in Ghana.

Environmental concerns are also linked to energy issues such as the use of alternative fuels to generate electricity and energy efficiency. Alternative fuels are defined in different ways, but are often alternatives to conventional fuels. There are usually environmental or energy-related benefits associated with alternative fuels. For example, natural gas used as a transportation fuel is considered an alternative that can be cleaner than conventional gasoline, but natural gas for power generation is not considered to be an alternative fuel (it is considered by many to be a cleaner fuel). Alternatives for power generation include hydroelectric power, solar electricity, wind energy, biomass energy and geothermal power. The fuels for each of these are available at little or no cost but they are often renewable fuels and they may produce little in any direct emissions. Proponents argue that the environmental costs of conventional electric power are not reflected in the cost of electricity produced. If these costs (externalities) were included, alternative fuel electricity would be very competitive (ISSER, 2005).

Review of Theoretical Literature

Reviewing the relationship between electricity consumption and economic growth is necessary to explain the causality between these variables. For this reason, theoretical literature relating to energy economics is examined. In this section, the theoretical literature in energy economics is discussed according to, the mainstream theory of growth and the causal relationship between energy consumption and economic growth.

The Mainstream Theory of Growth

Theoretical work on economic growth dates back many centuries ago. Although classical economists like Smith, Malthus and Ricardo did not formally study economic growth, however, they outlined the basic ingredients of economic growth. Recent neoclassical economists regarded as pioneers of economic growth analysed economic growth with rigorous models. They include Ramsey (1928), Solow (1956), and Swan (1956), while Romer (1986) and Lucas (1988) initiated economic growth theories that are known as endogenous growth theories. However, there is an inbuilt bias in mainstream growth theory that down play the role of resources in the economy, though there is nothing inherent in economics that restricts the potential role of resources in the economy.

The Basic Growth Model

The most simple growth model which examines the hypothetical economy is the model developed by Solow (1956) and Swan (1956), which is referred to as the neoclassical growth model. The model is assumed to be a function of capital, labour and technology. The critical assumption of the model is that the production function has constant returns to scale, exhibits positive and diminishing marginal products with respect to each input and satisfies the properties that the marginal products of inputs approaches infinity as inputs go to zero and approaches zero as inputs go to infinity. By assuming a constant rate of saving and diminishing returns to capital, the model predicts that growth in the long-run is a function of only technical change and not of savings or investment. According to the Solow model, saving will have an effect on the level of income but not on its growth rate. This prediction implies that in the absence of continuous improvement in technology, per capita growth will eventually cease (Stern, 2003).

Another important neoclassical growth theory, beside the Solo-Swan model, is the Ramsey model. The Ramsey model is a refinement of the Solow-Swan model. Chronologically, Ramsey's growth theory was developed before the Solow-Swan's. In the literature, however, his model is usually put after the Solow-Swan's. One of the key features in his model is the assumption that households optimise their utility over time. This assumption essentially makes the model dynamic. Using Ramsey's model as their starting point, Cass (1965) and Koopmans (1965) recast the saving rate that is exogenous under Solow-Swan model as endogenous. Even though this is considered a refinement of the neoclassical growth model, it does not eliminate the dependence of the long-run growth rate on exogenous technological progress (Solow, 1956). The works of

Cass and Koopmans (1965) actually mark the end of the basic neoclassical growth era.

The simple growth model described does not explain how improvements in technology come about. The model just assumed that it happens exogenously, so this model is said to have exogenous technological change. More recent models attempt to endogenize technological change by explaining technological progress as the outcome of decisions taken by firms and individuals. It was first started by the work of Romer (1986) and Lucas (1988). Unlike the Solow-Swan model in which the long-run growth rate is determined by an exogenous technological progress, Romer and Lucas suggest a model that endogenises the growth rate of the economies. Models that have endogenous source of per capita economic growth are called the endogenous-growth models.

Endogenous growth models are similar to the neoclassical models but they differ considerably in their underlying assumptions and suggested conclusions. Three distinctions between the two are obvious: First, the neoclassical assumption of diminishing marginal returns to capital is discarded. Second, the model also envisages increasing returns to scale in aggregate production, and third, the model recognizes the role of externalities in determining the rate of return on capital. In endogenous growth models, the relationship between capital and output can be written in the form Y = AK. Where A can be interpreted as representing any factor that affects technology, while K represents both human and physical capital. Unlike the neoclassical model, the endogenous growth theorists consider the term A in the expression as a constant, and so growth can continue indefinitely as capital is accumulated (Romer, 1956).

According to the endogenous growth model, technological knowledge is thought of as a form of capital and it is accumulated through research and development (R&D) and other knowledge creating processes. A firm increase technological knowledge through investment in capital. Each firm‘s technological knowledge has two special properties. First it is a public good such that the stock of it is not depleted with use and more is available for others at zero cost and secondly, it generates positive externalities in production. This means that whilst the firm doing R&D obtains benefits from the knowledge acquired, others benefit too –indicating that the benefits that the firm accrues when it learns and innovates are only partly appropriated by itself. There are beneficial spillovers to the economy from the R&D process so that the social benefits of innovation exceed the private benefits to the original innovator (Lucas, 1988).

So in an endogenous growth model, technological knowledge through investment in capital exactly offset the diminishing returns to manufactured capital and the economy can sustain a constant growth rate. So growth in this case is permanently influenced by the savings rate therefore a higher savings rate increases the economy’s long run growth rate.

Growth Models with Resources and no Technical Change

The mainstream theory of economic growth discussed pays little attention to the role of energy in economic growth. However, adding non renewable natural resources that are essential in production to the basic mainstream growth models means that capital also needs to be accumulated to compensate for resource depletion. All natural resources exist in finite quantities. Some of the resources are non-renewable and many renewable such as energy are also finite. Finiteness and exhaustibility of resources poses problems especially to economic growth (Stern, 1999).

The neoclassical literature about economic growth is mainly concentrated on which conditions permit continuing growth. Technical and institutional however determine whether growth is continous or not. Technical conditions include the mix of renewable and non renewable resources, the initial endowments of capital and natural resources, and the ease of substitution among inputs. The institutional setting on the other hand includes market structure (competition versus central planning), the system of property rights (private versus common property, etc.), and the system of values regarding the welfare of future generations (Stern, 2003).

When the natural resources are exhausted, they are replaced by their substitutes or by equivalent forms of human-made capital (people, machines, factories, etc.) for production. Neoclassical economists concern themselves with what institutional arrangement provide for continuing growth, on the other hang they ignore the impact of technical arrangement. That is, they only assume that substitutability is achievable in a model with only a nonrenewable natural resource with no extraction costs and non depreciating capital when the elasticity of substitution between the two inputs is unity, and when certain other technical conditions are met (Solow, 1956).

To the neoclassical, though substitutability is technically feasible, they were only interested in which institutional arrangements provide continuing economic growth.

Growth Models with Resources and Technical Change

In addition to substitution of capital for resources, technological change might permit growth or at least permit constant consumption in the face of a finite resource base. Stiglitz showed that, when the elasticity of substitution between capital and resources is unity, exogenous technical progress will allow consumption to grow over time if the rate of technological change divided by the discount rate is greater than the output elasticity of resources (Stiglitz, 1974). The increase in total productivity technically increases the ease of substitutability of economy and substitutability can enable technological change even with an elasticity of substitution of less than one. However, technical feasibility does not mean that there will be sustainability. Technical improvement means increase in the quantity of output for each unit of inputs.

Studies that examine the role of resource in growth with endogenous technical change such as Smulders and de Nooij (2003), and Aghion and Howitt (1998) have been less than the studies with the exogenous technology change or no technological change assumptions. Studies with endogenous technological change have not yet provided conditions for the achievement of substitutability (Stern, 2003).

In a study by Aghion and Howitt (1998) about the role of natural resources in production, they authors used four different models to examine whether sustainable growth will be achieved or not. First two models cover renewable resources, the other two cover non-renewable resources. In the models which cover non-renewable resources, it is assumed that non-renewable resources are important for production. Conversely, in the models which cover renewable resources, the resource which decreases the amount of pollution of the environment has more importance than non-renewable ones.

Tahvonen and Salo (2001) also developed a model which covers renewable and non-renewable energy resources at the same time. This model is more realistic than the previous neoclassical approach. They intend to see how the growth process would actually work. The extraction costs for fossil fuels and the costs of production for renewable resources are included in the model. This model also investigated the situation in which there is no technological change, thus, technological change is assumed to be exogenous. The study also assumed that increase in extraction leads to increase in technological knowledge and that technological knowledge increases the capital stock. The optimal development in such an economy appears to mimic history much more effectively than the neoclassical models. When the economy is divided by pre-industrial, industrial and post-industrial eras, fossil fuels usage rises in the first two eras and then falls as capital accumulation rises. The price of non-renewable energy resources first falls and then rises.

Ayres and van den Bergh (2005) also proposed a more disaggregated view on growth engines or mechanisms. They offered a model of economic growth with energy resources and dematerialization, and considered three growth mechanisms: firstly, the resource use (fossil fuel) growth engine, secondly, the scale-cum-learning growth mechanism and finally, the value creation (dematerialization) growth engine. They concluded that for sufficiently high growth rates, the required resource input must increases linearly with income. They argued that although theoretical results provide insufficient information on future patterns of growth in relation to resource use, the relevant policy tool is R&D investment, supplemented by regulation as applied to natural resource utilization, especially energy use efficiency and dematerialization.

Smulders and de Nooij (2003) further argued that energy use has a positive growth rate apart from a possible on-time reduction in the level of energy use. To them, the level of technology affects the use of energy, while the availability of investment capital has considerable impact on the energy consumption and economic growth.

Energy Consumption and Economic Growth

The study of the empirical investigations into the causal relationships between energy consumption and economic growth can be analysed through two lines; the hypothesis criteria (Apergis and Payne, 2009) and the generation criteria

(Guttormsen, 2004). The hypothesis approach analyses the causation in light of whether studies concluded that energy (electricity) consumption causes economic growth or otherwise or both. Along these lines, studies on the empirical investigation into the energy (electricity) and economic growth nexus have been grouped into four; the Growth-led-Energy hypothesis, the Energy led-Growth hypothesis, the Energy-led-Growth-led-Energy hypothesis, and the neutrality hypothesis (Adom, 2011).

The Growth-led-Energy hypothesis asserts that economic growth leads to energy consumption. This implies that even severe energy crisis will not retard economic growth, hence energy conservation measures are a viable option. The Energy-led-Growth hypothesis asserts that energy consumption leads to economic growth. This suggests that severe energy crisis will retard economic growth, hence energy conservation measures are not a viable option. The Energy-led-Growth-led-Energy hypothesis asserts that there exists bidirectional causality between energy consumption and economic growth. Lastly, the neutrality hypothesis asserts that there is no causal relationship between energy consumption and economic growth (Apergis and Payne, 2009).

Along the lines proposed by Guttormsen (2004), studies on the empirical investigations into energy and economic growth have been classified along three lines; the first generation studies, the second generation studies, and the third generation studies. The first generation studies consist of studies that basically used the traditional Vector Autoregressive Models and the standard Granger causality test. The main weakness associated with this generation of studies is that they assume the series to be stationary. As a result the second generation of studies proposed cointegration as the appropriate tool to use in analyzing the causal relationship between energy consumption and economic growth. Thus, in the second generation of studies, pairs of variables were tested for cointegration relationship and an error correction model was estimated to test for causality (Engle and Granger, 1987). However, given the possibility of more than one cointegrating vectors, the second generation studies approach was deemed inappropriate (Granger, 1988).

This led to the third generation of studies, which proposed a multivariate approach that allowed for more than two variables in the cointegrating relationship. This approach facilitates estimations of systems where restriction on cointegrating relationship can be tested and information on short-run adjustment can be investigated. There are two main problems with the third generation studies. First, the third generation studies impose restrictions that the variables should be integrated of order one. Secondly, the variables will have to be cointegrated before a test of causality can be possible. This has led to the fourth generation of studies. These studies use the Toda and Yomamoto Granger Causality test, which is based on the Autoregressive distributed lag model. In this generation of studies, restrictions are not imposed on the variables. Thus, causality is still possible even when variables are integrated of order zero, one or both. In other words, this approach allows for the test of causality even when variables are not cointegrated (Adom, 2011).

In addition to the above, Ozturk and Acaravci (2010) in a literature survey on the energy-growth nexus classified the various studies into country-specific and multi-country studies on energy (electricity consumption) and economic growth. The general observation according to this study is that the results emanating from the multi-country studies and country-specific studies on the causality between energy consumption and economic growth reveals contradictory results. However, the results from the country-specific studies on the causality between electricity consumption and economic growth reveals that there exists a positive causality which runs from electricity consumption to economic growth but the multi-country studies on the causality between electricity consumption and economic growth shows contradictory results.

Review of Empirical Literature

The causal relationship between electricity consumption and economic growth has been a debated subject of the extensive empirical literature in the past three decades. However, no common consensus neither on the existence nor on the direction of the causal relationship between electricity consumption and economic growth has emerged. This depends on institutional, structural and policy differences of the countries involved, variety of variables and data span chosen and methodological differences. The aim of this section is to summarize the empirical literature of causality relationship between electricity consumption and economic growth and present the inconsistency of these studies.

The pioneering study by Kraft and Kraft (1978) using Sims's technique found evidence of unidirectional causality, only running from gross national product (GNP) to energy (electricity) consumption for the United States (US) over the period 1947-1974. Therefore the US economy as at that time frame is not energy (electricity) dependent. It implies that policies aimed at reducing electricity consumption can be implemented with little adverse or no effect on economic growth.

On the other hand, Akarca and Long (1980) showed that there is no causal relationship between energy consumption and economic growth when the sample time period is shortened by 2 years in the US economy. The techniques used to analyze the dynamic relationships between these two economic series in the study included cross-correlation functions based on the double-filter and single-filter, the haugh test of independence, the Sim's test of causality and the generalized Box-Jenkins procedure of multiple time series modeling. The study concludes that energy conservation does not lead to an increase or decrease in total employment.

Yu and Hwang (1984) also found evidence in support of the neutrality hypothesis that there is no causal relationship between energy consumption and GNP in US using the Sims' and Granger causality test when the sample period is extended by 5 years. It implies that energy consumption is not correlated with GNP, so that energy conservation policies do not affect GNP. In a similar study, Yu and Choi (1985) examined the causal linkage between GNP and the aggregate and as well as several disaggregate categories of energy consumption including solid fuels, liquid fuels, natural gas, and electricity for five countries with various stages of economic development for the time period 1950-1976 based on Sims and Granger tests of causality. This study indicates unidirectional causality from aggregate energy consumption to GNP for the Philippines and from GNP to aggregate energy consumption for South Korea but no causality in either direction for the USA, the United Kingdom (UK), and Poland is found. If causality only runs from energy consumption to GNP, then it implies that the economy is energy dependent and the shortage of the energy may negatively affect economic growth.

Erol and Yu (1987) also use the results of the Sims and Granger causality tests between energy consumption and GNP in some industrialized countries for the period 1950-1982 to conclude a unidirectional causality running from energy consumption to GNP for Canada, from GNP to energy consumption for both West Germany and Italy, neutrality of energy consumption with respect to GNP for France and UK and a bidirectional causality in Japan.

Stern (1993) uses a multivariate approach rather than a bivariate approach to examine the Granger causality between GDP and energy consumption using vector autoregressive (VAR) model of GDP, energy use, capital stock, and employment for the period 1947-1990 in USA. Stern uses GDP instead of GNP and a quality-adjusted index of energy input rather than gross energy use different from many previous studies. As Glasure and Lee (1997) argue that the use of GDP is better than the GNP since the country's total energy consumption depends on goods and services produced within the country, not outside the country. Stern (1993) finds that energy consumption Granger causes GDP. This result contradicts the previous results for USA and the changes may probably be caused by variation in the variables and in the time span.

Ebohon (1996) tests the Granger causality between electricity consumption and economic growth that is proxied by GDP and GNP for two countries, Tanzania over the period 1960 to 1984 and Nigeria over the period 1960 to 1981. The result of the study reveals bidirectional causality between electricity consumption and economic growth for both nations. This means that, unless energy supply constraints are eased, economic growth and development will remain elusive to these countries. The finding of the study supports the view that energy consumption plays an important role in the economic development of countries.

Nachane, Nadkarni and Karnik (1998) first use the cointegration theory to test the existence of the long run equilibrium relationship between energy consumption and economic growth using GDP as a proxy. The study also shows the strength of the causal relationship. Conversely, previous studies only indicate the causal relationship between the variables. Nachane et al. (1998) study the relationship between energy consumption and economic growth for 25 countries for the period 1950 to 1985 but cointegration can only be established for 16 countries (11 developing and 5 developed countries). Bidirectional causality is found by using the Sims' and Granger causality tests for all countries except Colombia and Venezuela.

Yu and Jin (1992) also examined the bivariate cointegration between energy consumption and income or employment using monthly USA data over the period 1974 to 1990. They found that cointegration fails to exist between them for either energy consumption-income or energy consumption-employment relationship by using Engle-Granger two step procedure. This implies that energy consumption is neutral with regard to income and employment over the long-run. This analysis is consistent with the earlier conclusions in the literature for the economy that energy consumption policies do not affect the growth in the short run.

Stern (2000) extends his previous study of USA in the post-war period by adding multivariate cointegration relationship between energy consumption and GDP. The results show that cointegration does occur and that energy input cannot be excluded from the cointegration space. Stern concludes that there is a unidirectional causality from energy consumption to GDP. This means that energy consumption is a limiting factor for economic growth. This conclusion is similar to multivariate model of Stern (1993), while it contradicts the bivariate model of Yu and Jin (1992).

In a similar study, Ghosh (2002) investigated the Granger causality between electricity consumption per capita and Gross Domestic Product (GDP) per capita for India using annual data covering the period 1950–51 to 1996–97. The Phillips–Perron tests revealed that both series, after logarithmic transformation, are non-stationary and individually integrated of order one. The study found no strong evidence of long-run equilibrium relationship among the variables but there exists unidirectional Granger causality running from economic growth to electricity without any feedback effect. Ghosh therefore suggested that electricity conservation policies can be initiated.

Guttormsen (2004) also applied the causality test to empirically examine the causal relationship between primary energy consumption and real Gross National Product for Turkey during 1970–2006. The study employed unit roots tests; the augmented Dickey–Fuller (ADF) and the Philips–Perron (PP), Johansen cointegration test, and the Pairwise Granger causality test to examine the relationship between the series. The empirical results from the study indicated that the two series are non-stationary, however the first differences of the series led to stationarity. Further, the results indicated that energy consumption and GNP are cointegrated and there is bidirectional causality running from energy consumption to real GNP and vice versa. This means that an increase in energy consumption directly affects economic growth and that economic growth also stimulates further energy consumption.

Also, Akinlo (2009) examined the association between energy consumption proxied by electricity consumption and real GDP for the case of Nigeria during the period 1980-2006. The empirical evidence shows cointegration for both variables and electricity consumption Granger causes real GDP. The results of Hodrick–Prescott (HP) filter used by the study also decompose the fluctuations from the series of electricity consumption and economic growth. The estimation results showed that there is cointegration between the trend and the cyclical components of the two series, which seems to suggest that the Granger causality is possibly related with the business cycle. The paper therefore suggested that investing more and reducing inefficiency in the supply and the use of electricity can further stimulate economic growth in Nigeria.

Odhiambo (2009) examined the causal relationship between electricity consumption and economic growth in South Africa covering the years 1971-2006. The study incorporated the employment rate as an intermittent variable in the bivariate model between electricity consumption and economic growth, thereby creating a simple trivariate causality framework. The empirical results showed that there is bidirectional causality between electricity consumption and economic growth in South Africa. In addition, the results showed that employment in South Africa Granger-causes economic growth. It is observed from the study that the results apply irrespective of whether the causality is estimated in the short-run or in the long-run formulation. The study, therefore, recommends that policies geared towards the expansion of the electricity infrastructure should be intensified in South Africa in order to cope with the increasing demand exerted by the country's strong economic growth and rapid industrialization programme. Odhiambo’s findings of a bidirectional relationship between electricity consumption and economic growth parallel the results obtained by Jumbe (2004) for Malawi.

Belloumi, (2009) in a related study used the Johansen cointegration technique to examine the causal relationship between per capita energy consumption and per capita gross domestic product for Tunisia during the 1971–2004 period. In order for the study to test for Granger causality in the presence of cointegration among the variables, a vector error correction model (VECM) is used instead of a vector autoregressive (VAR) model. The estimation results indicated that the per capita gross domestic product and per capita energy consumption for Tunisia are related by one cointegrating vector and that there is a long-run bidirectional causal relationship between the two series and a short-run unidirectional causality from energy to gross domestic product.

Similarly, Ighodaro (2010) reexamined cointegration and causality relationship between energy consumption and economic growth for Nigeria using data covering the period 1970 to 2005. Unlike previous related study for Nigeria, different proxies of energy consumption (electricity demand, domestic crude oil consumption and gas utilization) were used for the estimation. The study included government activities proxied by health expenditure and monetary policy proxied by broad money supply though emphasis was on energy consumption. Using the Johansen co-integration technique, the study found that there exist a long run relationship among the series and all the variables used for the study were found to be I(1). Furthermore, unidirectional causality was established between electricity consumption and economic growth, domestic crude oil production and economic growth as well as between gas utilization and economic growth in Nigeria. While causality runs from electricity consumption to economic growth as well as from gas utilization to economic growth, it was found that causality runs from economic growth to domestic crude oil production. The result of unidirectional causality from electricity consumption to economic growth is consistent with the result obtained by Akinlo (2009).

Masih and Masih (1996) used the cointegration results between energy consumption and economic growth in testing Granger causality for Asian countries. Long-run energy and income relationship is only held for India, Pakistan, and not for Malaysia, Singapore and the Philippines. With the aid of cointegration and VECM, they found unidirectional causality from energy consumption to GDP for India, exactly the reverse for Indonesia and bidirectional causality for Pakistan. On the contrary, they did not find any direction of causality between these two variables by applying VAR model for the three non-cointegrated countries.

Glasure and lee (1997) examined the causal relationship between energy consumption and GDP for South Korea and Singapore over the period 1961 to 1990 by using cointegration and VECM and VAR-based standard Granger causality test. The result of VAR indicated no causality between energy consumption and GDP for South Korea and unidirectional causality from energy consumption to GDP for Singapore. In contrast, the result of VECM revealed bidirectional causality between energy consumption and GDP, because standard Granger causality test is not able to estimate long run relationship.

Masih and Masih (1997) reexamined the causality analysis of energy consumption and economic growth based on the demand side multivariate model. The study used trivariate variables of energy consumption, GDP, and consumer price index as a proxy for real energy price rather than bivariate system of energy consumption and GDP. The trivariate model applied in the study is different than the production side model which consisted of energy consumption, GDP, capital, and labour in Stern's (1993) studies. Their cointegration and VECM results indicated that there exists a long-run equilibrium relationship among energy consumption, GDP, and price and bidirectional causality between energy consumption and GDP for both in South Korea and Taiwan.

Furthermore, Masih and Masih (1998) used multivariate cointegration and error correction modeling techniques to estimate the causal relationship for two Asian less-developed countries: Thailand and Sri Lanka. They discovered that energy consumption, GDP, and price are cointegrated and there is a unidirectional causality from energy consumption to GDP and price. Therefore energy consumption is relatively exogenous variable in these countries. Cheng (1999) uses Granger causality, cointegration and error correction approach for India during 1952-1995. The cointegration test revealed that energy consumption, GNP, capital and labour are cointegrated and economic growth unidirectionally Granger causes energy consumption both in the short run and in the long run. The result of the study contradicts with Masih and Masih's (1998) results by finding unidirectional causality from energy consumption and economic growth for Thailand and Sri Lanka. Variables and time period are different in these studies.

Asafu-Adjaye (2000) in a similar study tested the causal relationship between energy consumption and GDP by using a model based on demand functions that includes energy consumption, GDP, and price in four Asian developing countries (India, Indonesia, the Philippines and Thailand). The results indicated that, in the short-run, unidirectional Granger causality runs from energy to income for India and Indonesia, while bidirectional Granger causality runs from energy to income for Thailand and the Philippines. In the case of Thailand and the Philippines, energy, income and prices are found to be mutually causal. The study results did not support the view that energy and income are neutral with respect to each other, with the exception of Indonesia and India where neutrality was observed in the short-run. Asafu-Adjaye's results for Indonesia, the Philippines, and India are different from the result of Masih and Masih (1996) and Cheng (1999). However Asafu-Adjaye's result for India is consistent with the finding of earlier study done by Masih and Masih (1996).

Glasure (2002) applies five variable VECM consisting of real money supply a proxy for monetary policy, real government expenditure a proxy for government activity, dummy variable for the two oil price shocks, real oil price, energy consumption, and GDP to investigate the link between energy consumption and GDP for Korea by using VECM. He uses yearly data for the period 1961-1990 to conclude a bidirectional causality running between energy consumption and GDP. This result for Korea is similar to results of the Masih and Masih (1997) and Glasure and lee (1997) studies which show the bidirectional causality between energy consumption and economic growth.

In a related study, Shiu and Lam (2004) employed Johansen and Juselius cointegration and short run Granger causality approaches for cointegration to examine the direction of causality between electricity and GDP per capita for China for the period 1978–2004. The estimation results indicated that real GDP and electricity consumption for China are cointegrated and there was only unidirectional Granger causality running from electricity consumption to real

GDP but not the vice versa. Then Hodrick–Prescott (HP) filter was applied to decompose the trend and fluctuation component of the GDP and electricity consumption series. The estimation results indicated that there is cointegration between not only the trend components, but also the cyclical components of the two series, which implies that, the Granger causality is probably related with the business cycle. Moreover, Jumbe (2004) applies Granger causality test, cointegration and error correction approach for discussing the relationship between various kinds of GDP, including overall GDP, agricultural GDP, and non-agricultural GDP and electricity consumption for Malawi during 1970-1999. The Granger causality results indicated bidirectional causality between electricity consumption and overall GDP and a unidirectional causality relationship running from non-agricultural GDP to electricity consumption. On the other hand, the VECM results showed a unidirectional causality from overall GDP and non-agricultural GDP to electricity consumption

Oh and Lee (2004a) employed cointegration and vector error correction modeling techniques to estimate the causal relationship between energy consumption and economic growth in Korea for the period 1970-1999. By applying multivariate module of energy consumption, GDP, capital, and labour, they found unidirectional causality running from energy consumption to economic growth in the short run and bidirectional causality between energy consumption and GDP in the long run. Oh and Lee (2004b) again used quarterly data over the period 1981-2000 for Korea. They applied cointegration and VECM on two multivariate models: one a demand side model and the other a production side model. In their results, VECM shows no causal relationship for energy consumption and GDP in the short run but bidirectional causal relationship between energy consumption and GDP in the long run. When the time period is changed, they find contradictory causality results for Korea.

Paul and Bhattacharya (2004) empirically examined the relationship between electricity consumption and economic growth using monthly India data from 1950 to 1996. Their empirical results revealed a short-run unidirectional causality from energy consumption to GDP using standard Granger causality test, a long-run unidirectional causality form GDP to energy consumption using Engle-Granger cointegration approach and a short-run unidirectional causality from GDP to energy consumption using Johansen cointegration approach. The results of standard Granger causality test combine with the Engle-Granger cointegration approach are same as the results of Johansen cointegration approach.

Similarly, Jamil and Ahmad (2010) empirically examined the relationship among electricity consumption, its price and real GDP at the aggregate and sectoral level in Pakistan. Using annual data for the period 1960–2008, the study found the presence of unidirectional causality from real economic activity to electricity consumption. In particular, growth in output in commercial, manufacturing and agricultural sectors were found to increase electricity consumption, while in residential sector, growth in private expenditures was the cause of rising electricity consumption. The study concludes that electricity production and management needs to be better integrated with overall economic planning exercises. This is essential to avoid electricity shortfalls and unplanned load shedding.

Twerefo et al (2008) also utilized the technique of cointegration and vector error-correction modeling to examine the link between electricity consumption and economic growth in Ghana. The results suggested that GDP in Ghana indeed Granger causes electricity consumption and that the causality is unidirectional. The study advocated that electricity conservation is a viable option for Ghana. Akinlo (2008) also explored the causal relationship between energy consumption and economic growth for eleven Sub-Saharan African countries. Using the autoregressive distributed lag (ARDL) bounds test, the study found that energy consumption is cointegrated with economic growth in Cameroon, Cote D'Ivoire, Gambia, Ghana, Senegal, Sudan and Zimbabwe. Moreover, the test suggested that energy consumption has a significant positive long run impact on economic growth in Ghana, Kenya, Senegal and Sudan. Granger causality test based on the vector error correction model (VECM) showed that there is bidirectional relationship between energy consumption and economic growth for Gambia, Ghana and Senegal. However, Granger causality test revealed that economic growth Granger causes energy consumption in Sudan and Zimbabwe. The neutrality hypothesis is confirmed in respect of Cameroon and Cote D'Ivoire. The same result of no causality was found for Nigeria, Kenya and Togo. The result showed that each country should formulate appropriate energy conservation policies taking into cognizance of her peculiar condition.

Cheng (1995) studies the temporal causal relationship between energy consumption and economic growth for the USA in 1947-1990 based on both bivariate and multivariate model. Case of non-causality is found in the USA using Hsiao's version of the Granger causality for both bivariate model of energy consumption and GDP and multivariate model of energy consumption, GDP, and capital.

Test of the causal relationship between energy consumption and economic growth in three Latin American countries applying Hsiao's version of the Granger causality is the subject of the study by Cheng (1997). His results indicated no causality in either direction in Mexico for the 1949-1993 periods and in Venezuela for the 1952-1993 period in a multivariate model. However, in Brazil, for the 1963-1993 period, Cheng (1997) revealed a unidirectional causal relationship running from energy consumption to GDP without feedback in his bivariate model. In addition, capital was found to negatively, though weakly, causes economic growth for both Mexico and Venezuela.

Cheng and Lai (1997) empirically examined the causality between energy consumption and economic growth in a bivariate model for Taiwan over the period 1955 to 1993. The Phillips-Perron tests employed in the study revealed that the series with the exception of GNP are not stationary and therefore differencing is performed to secure stationarity. They found no cointegrating relationship between energy consumption and GDP. The results of Hsiao's version of the Granger causality methodology indicated that there is unidirectional causality from GDP to energy consumption without any feedback in Taiwan. Yang (2000) also tested the causal relationship between income and various kind of energy consumption in Taiwan using 1954-1997 data. Using cointegration and Hsiao's version of the Granger causality, the estimation results indicated bidirectional causality between energy consumption (total, coal and electricity) and GDP, unidirectional causality running from GDP to oil consumption and unidirectional causality from gas consumption to GDP. His result for total energy consumption and GDP does not support the previous finding of Cheng and Lai (1997) of unidirectional causal relationship running from GDP to energy consumption.

Cheng (1998) again applied the Hsiao's version of Granger causality test to investigate the causality between energy consumption and GNP for Japan in 1952-1995 based on production side model of energy consumption, GNP, employment and capital. The study found employment, energy consumption, Real GNP and capital not cointegrated. However, electricity consumption was found to negatively Granger causes employment whereas employment and real GDP are found to directly Granger causes electricity consumption. It is also found in the study that capital negatively Granger causes employment while Real GNP and employment are found to strongly influence electricity consumption. The findings of this study seem to suggest that a policy of energy conservation may not be detrimental to a country such as Japan. In addition, the finding that energy and capital are substitutes implies that energy conservation will promote capital formation, given that output is constant.

Aqeel and Butt (2001) also investigated the causal relationship between energy consumption and economic growth and energy consumption and employment in Pakistan for the period 1955 to 1996. By applying techniques of cointegration and Hsiao's version of Granger causality, the study concluded that there is no cointegration between the variables and unidirectional causality is found running from GDP to total energy and oil consumption and unidirectional causality running from electricity consumption to GDP.

Altinay and Karagol (2004) empirically examined the causal relationship between electricity consumption and real GDP in Turkey during the period of 1950–2000 by applying bivariate model. Their study indicated that energy consumption and GDP are stationary series with different structural breaks by the Zivot and Andrews test and there is no evidence of causality relationship between energy consumption and GDP using Hsiao's version of the Granger causality test.

Yoo (2006) also employed cointegration and Hsiao's version of the Granger causality tests to empirically examine the causality relationship between electricity consumption and economic growth in the four countries of the association of south East Asian nations (ASEAN), namely Indonesia, Malaysia, Singapore, and Thailand by using data for the period 1971 to 2002. Evidence from the study showed that there is no cointegration relationship between electricity consumption and GDP for all countries but there is a bi-directional causality between electricity consumption and economic growth in Malaysia and Singapore. This means that an increase in electricity consumption directly affects economic growth and that economic growth also stimulates further electricity consumption in the two countries. However, unidirectional causality was found running from economic growth to electricity consumption in Indonesia and Thailand without any feedback effect.

Chontanawat, Hunt and Pierse (2006) used the cointegration and Hsiao's version of Granger causality methodology to analyse the causal relationship between energy consumption and output for 30 OECD countries over the period 1971-2000 and 78 non-OECD countries over the period 1971-2000. This is actually the first of such a large number of countries. Causality from aggregate energy consumption to GDP and GDP to energy consumption is found to be more prevalent in the developed OECD countries compared to the developing non-OECD countries; implying that a policy to reduce energy consumption aimed at reducing emissions is likely to have greater impact on the GDP of the developed rather than the developing world.

Chebbi and Boujelbene (2008) in a similar study reinvestigated the cointegration and causality link between energy consumption and agricultural and non-agricultural outputs. In the study, ADF and KPSS, Johansen and VECM methods are used for 1971-2003 period in Tunisia. Empirical results suggest that there is only unidirectional causality running from agricultural and non-agricultural sectors to energy consumption. This unidirectional causality signifies a less dependent energy dependent economy for Tunisia.

Fatai, Oxley and Scrimgeour (2001) empirically examined the causal relationship between GDP and various categories of energy consumption in New Zealand for the period 1960-1999 and the results are compared with Australia and several other Asian economies. They used the standard Granger causality and a modified version of Granger causality proposed by Toda and Yamamoto for New Zealand and the results are similar with both methodology. They found unidirectional causality running from GDP to industrial and total energy consumption. The standard Granger causality test, the Toda-Yamamoto approach and the ARDL approach were also applied for Australia. They discovered unidirectional causality running from GDP to coal, electricity and final energy consumption using the standard Granger causality test and the Toda-Yamamoto test. On the other hand, the result for coal consumption and GDP is inconclusive for the ARDL approach. From the results, energy conservation policies may not have significant impacts on real GDP growth in industrialized countries such as New Zealand and Australia compared to the other Asian economies.

Wolde-Rufael (2004) also investigated the causal relationship between various kinds of industrial energy consumption and GDP in Shanghai for the period 1952–1999 using a modified version of the Granger (1986) causality test proposed by Toda and Yamamoto. The empirical evidence from the disaggregated energy series suggested that there was a unidirectional Granger causality running from coal, coke, electricity and total energy consumption to real GDP but no Granger causality running in any direction was found between oil consumption and real GDP.

Wolde-Rufael (2005) again studied the causal relationship between energy consumption and economic growth for 19 Africa countries between 1971 and 2001. The Toda-Yamamoto test results indicated a bidirectional causality for energy consumption and GDP for Gabon and Zambia, a unidirectional causality from GDP to energy consumption for Algeria, Democratic Republic of Congo, Egypt, Ghana and Ivory Coast, unidirectional but reserved causality for Cameroon, Morocco, and Nigeria and neutral relationship for Benin, Republic of Congo, Kenya, Senegal, South Africa, Sudan, Togo, Tunisia and Zimbabwe.

Altinay and Karagol (2005) again used the standard Granger causality test and Dolado-Lukepohl test to examine the causal relationship between electricity consumption and economic growth for Turkey using annual data covering the period 1950-2000. Zivot and Andrews's unit roots test with endogenous structure breaks employed in the study indicated that both series were stationary with different structural breaks. The study used both Toda Yamamoto and the Dolado-Lukepohl causality and the results from both tests suggested strong evidence of unidirectional causality running from electricity consumption to GDP. This implies that the supply of electricity is vitally important to meet the growing electricity consumption in Turkey.

In another study, Wolde-Rufael (2006) reinvestigated the long-run and causal relationship between electricity consumption per capita and real gross domestic product (GDP) per capita for 17 African countries for the period 1971–2001 using ARDL cointegration test proposed by Pesaran et al. (2001) and a Granger causality test due to Toda and Yamamoto. The empirical evidence shows that there exists a long-run relationship between electricity consumption per capita and real GDP per capita for only 9 countries and Granger causality for only 12 countries. For 6 countries, there was a positive unidirectional causality running from real GDP per capita to electricity consumption per capita; an opposite causality for 3 countries and bi-directional causality for the remaining 3 countries.

Squalli and Wilson (2006) investigated the electricity consumption and income hypothesis for Bahrain, Kuwait, Osman, Qatar, South Korea and United Arad Emirates. The paper used the bounds test procedure suggested by Pesaran et al (2001) and Toda and Yamanto non-causality approach to test for the long-run relationship. The data used in this study were yearly and it ranges from 1980-2003. This paper finds evidence of a long-run relationship between electricity consumption and economic growth for all the countries. It also finds support for the efficacy of energy conservation measures in 5 of the 6 countries except Qatar.

Ciarreta and Zarraga (2007) investigated linear and nonlinear causality between electricity consumption and economic growth in Spain for the period 1971 to 2005. Applying both standard Granger causality and Dolado-Lukepohl methodology, they found evidence of unidirectional linear causality running from GDP to electricity consumption. By contrast, the study found no evidence of nonlinear Granger causality between the series in either direction.

Zachariadis (2007) applied different Granger causality test methods such as VEC, ARDL and Toda-Yamamoto to test causal relationship between GDP and total energy use as well as sectoral energy consumption for G-7 countries namely Canada, France, Germany, Italy, Japan, the United Kingdom and the United States, using aggregate and sectoral data over different time periods. The results of these three models were in agreement for the US but inferred large disparity for all other countries.

Combo (2008) also computed the direction and the dynamic interrelationship between electricity infrastructure and real GDP in the Mexican economy during 1937-2007. To test the direction and dynamics of such causality, a battery of parametric tests and non-parametric methodologies were applied. To test causality, the study used Granger causality test based in an error correction model, as well as on the methodology proposed by Dolado-Lukepohl of an unrestricted VAR model. The results suggested that economic growth in Mexico preceded the expansion of the electricity infrastructure in most of the sample.

Furthermore, Chandran, Sharma and Madhavan (2009) also reinvestigated the link between electricity consumption and real GDP for the case of Malaysia. They have found cointegration among electricity consumption, consumer prices and real GDP by employing ARDL bounds testing. The results of the autoregressive distributed lag (ARDL) estimates of long-run elasticity of electricity consumption on GDP are found to be around 0.7 and statistically significant. Finally, in the short-run, the results of the causality test showed that there is a unidirectional causality which flows from electricity consumption to economic growth in Malaysia.

Also, the relationship between electricity consumption and economic growth is investigated by Abosedra, Dah and Ghosh (2009) using time series but monthly data covering the period January 1995 to December 2005 for the case of Lebanon. Empirical results of the study confirm the absence of a long-term equilibrium relationship between electricity consumption and economic growth in Lebanon but there exist unidirectional causality running from electricity consumption to economic growth when examined in a bivariate vector autoregression framework with changes in temperature and relative humidity as exogenous variables.

Adom (2011) also examined the causal relationship between electricity consumption and economic growth using a methodology based on the Toda-Yamamoto test for causality relationship and the bounds testing (ARDL). Using time-series data for the period 1971- 2008, the study found is unidirectional causality that runs from economic growth to electricity consumption for Ghana. The study also found a long-run relationship between electricity consumption and economic growth. This result is also consistent with the result obtain by Wolde-Rufael (2006) but contradict the result by Akinlo (2008).

Shahbaz and Lean (2011) also investigated the relationship among energy consumption, financial development, economic growth, industrialization and urbanization in Tunisia from 1971-2008. The autoregressive distributed lag bounds testing approach to cointegration and Granger causality tests were employed for the analysis of the study. The result confirmed the existence of long-run relationship between energy consumption, economic growth, financial development, industrialization and urbanization in Tunisia. Moreover, financial development, industrialization and urbanization were found to be positively related to energy consumption especially in the long-run. Long-run bidirectional causal relationships between financial development and energy consumption, financial development and industrialization, and industrialization and energy consumption were also revealed by the study.

Similarly, Ozturk and Acaravci (2011) using an ARDL Bounds cointegration approach investigated the relationship and the direction of causality between electricity consumption and economic growth for 11 Middle East and North Africa countries (MENA) from 1990-2006. The unit roots tests results indicated that some of the variables for Algeria, Jordan, Tunisia and United Arab Emirates do not satisfy the underlying assumptions of the ARDL bounds test approach of cointegration methodology. Therefore, before proceeding to the estimation stage, the study drops these countries from the ARDL bounds test approach of cointegration and the causality text analysis. The authors found no unique evidence of long-run equilibrium relationship between electricity consumption and economic growth in Iran, Morocco and Syria, hence, were eliminated from the sample. However, the study found the existence of level relationship between electricity consumption and economic growth for Egypt, Israel, Oman, and Saudi Arabia. The test of causality revealed a one way short-run Granger causality from economic growth to electricity consumption in Israel. In Egypt, Oman, and Saudi Arabia, the causality test revealed the existence of one-way both short and long-run Granger causality from electricity consumption to economic growth.

Shahbaz, Tang and Shabbir (2011) also examined the relationship between electricity consumption, economic growth, and employment in Portugal using the cointegration methodology and the study examined the presence of a long-run equilibrium relationship using the bounds testing approach to cointegration within the Unrestricted Error-Correction Model (UECM). Using the ARDL bounds test, the results shows that electricity consumption, economic growth, and employment in Portugal are cointegrated and there is bidirectional Granger causality between the three variables in the long-run. With the exception of the Granger causality between electricity consumption and economic growth, the rest of the variables also bidirectionally Granger causes each other in the short-run. Furthermore, the study found that there is unidirectional Granger causality running from electricity consumption to economic growth, but no evidence of reversal causality in the short run is found.

Lee (2005) examined the causality issue between energy consumption and GDP for 18 developing countries over the period 1975 to 2001 using three different panal unit roots, heterogeneous panel cointegration and panel based error correction model. Empirical evidence based on the trivariate model of energy consumption, GDP and capital indicated that there exists a long run equilibrium relationship among these variables after adding specific heterogeneous country effects and energy consumption Granger causes GDP in both the short run and the long run. This result indicates that energy conservation may harm economic growth in developing countries regardless of being transitory or permanent.

Lee and Chang (2007) in a related study employed data on 22 developed countries from 1965 to 2002 and 18 developing countries from 1971 to 2002 to test the causal relationship between energy consumption and GDP growth. They used the panel stationary test with multiple structural breaks proposed by Carrion-i-Silvestre et al. (2005) and found both energy consumption and GDP series to be stationary series for both developed and developing countries. Applying panel

VAR, the study revealed a bidirectional causality causal relationship between energy consumption and economic growth for developed countries and unidirectional causal relationship running from economic growth to energy consumption for developing countries. Finally, from the impulse response functions, all of the variables in the panel VAR had a positive effect on each other, but their impact was greater and more persistent in developing countries. Their result for developing countries is inconsistent with the result of an earlier work done by Lee (2005).

In another study, Nondo and Kahsa (2009) investigated the long run relationship between energy consumption and GDP for a Panel of 19 African countries based on annual data for the period 1980-2005. The results showed that GDP and energy consumption are integrated of order one and they move together in the long run indicating that they are cointegrated. Their study estimated the long run relationship and the test of causality using panal-based error correction model. The results indicated that in the short run, the neutral hypothesis holds however in the long run causality is unidirectional, running from energy consumption to GDP.

Nguyen-Van (2010) also used the semi parametric partially linear panel model and Westerlund and Edgerton test, which allows for structural breaks in the panel to examine the relationship between energy consumption and income for the panel of 158 countries for the period 1980-2004. The results suggested that energy consumption increases with income but the effect of changes in energy consumption structure, specifically, the natural gas and petroleum share, is not significant.

Acaravci and Ozturk (2010) applied panel data to investigates the long-run relationship and causality issues between electricity consumption per capita and economic growth per capita in 15 transition countries (Albania, Belarus, Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Serbia, Slovak Republic and Ukraine) using the Pedroni panel cointegration test for the 1990–2006 period. The Pedroni panel cointegration tests employed by the study confirm no cointegration relationship electricity consumption per capita and economic growth per capita and hence the error-correction mechanisms and the causality tests could not be run for further steps in the long-term to investigate the causality between electricity consumption and economic growth.

Yoo and Kwak (2010) also applied the panel cointegration test to investigate the causal relationship between electricity consumption and economic growth among seven South American countries, namely Argentina, Brazil, Chile, Columbia, Ecuador, Peru, and Venezuela for the period 1975–2006. The results indicated that the causal nexus between electricity consumption and economic growth varies across countries. There is a unidirectional, short-run causality from electricity consumption to real GDP for Argentina, Brazil, Chile, Columbia, and Ecuador. This means that an increase in electricity consumption directly affects economic growth in those countries. In Venezuela, there is bidirectional causality between electricity consumption and economic growth. This implies that an increase in electricity consumption directly affects economic growth and that economic growth also stimulates further electricity consumption in that country. However, no causal relationships exist in Peru.

Apergis and Payne (2011a) examined the relationship between renewable and non-renewable electricity consumption and economic growth for 16 emerging market economies within a multivariate panel framework over the period 1990–2007. The Pedroni and heterogeneous panel cointegration tests employed in the study indicates that there is a long-run equilibrium relationship between real GDP, renewable electricity consumption, non-renewable electricity consumption, real gross fixed capital formation, and the labour force. However, the long-run elasticity estimate for renewable electricity consumption is positive, but statistically insignificant. The results from the panel error correction model revealed unidirectional causality from economic growth to renewable electricity consumption in the short-run and bidirectional causality in the long-run. Furthermore, there is bidirectional causality between non-renewable electricity consumption and economic growth in both the short and the long-run.

In another large panel model of 88 countries over the 1990~2006 period, Apergis and Payne (2011b) classifies income level into 4 panels (high, middle high, middle low, and low incomes) and employed a panel cointegration technique to discover cointegration relations among electricity consumption, real gross fixed capital formation, GDP and labour. The causality test of the VEC model employed by the study indicated a bidirectional causality relationship between electricity consumption and economic growth for high income and middle-high income panels. The results of the study also indicated that there was unidirectional causality between electricity consumption and economic growth in the short run for the middle-low panel but there exist a feedback relationship between them in the long run. Furthermore, the results of the study reveal that for low income panel, electricity consumption Granger causes economic growth.

Conclusion

This chapter reviewed relevant literature on the Ghanaian economy and its electricity sector development as well as theoretical and empirical work on the relationship between energy (electricity) consumption and economic growth. From the literature reviewed, it will be ambiguous to assign any positive or negative expectation on the impact of energy consumption on Economic growth in Ghana. This is due to the fact that the empirical literature on the nature and direction of causal relationships among the variables are inconclusive and mixed as a result of institutional, structural and policy differences of the countries involved, variety of variables and data span chosen as well as methodological differences. However, as shown by the review, growing body of empirical studies have demonstrated a strong positive link between energy (electricity) consumption and long-run economic growth.

CHAPTER THREE

METHODOLOGY

Introduction

The aim of this chapter is to develop and specify an empirical model that captures the relationship between electricity consumption and economic growth in Ghana.

Model Specification

In order to examine the relationship between economic growth and electricity consumption, an endogenous growth model in the form of a Cobb-Douglas production function is formulated as given in equation (1).

$$Y_t = AK_t^{\alpha} LF_t^{\beta} \qquad (1)$$

Where *Y* denotes the aggregate output at time *t*, *K* is the aggregate capital stock at time *t*, *LF* denotes labour force at time t while *A* denotes total factor productivity (TFP). α and β are the coefficients of elasticity for capital and labour respectively. The TFP captures growth in output not accounted for by increase in the physical input (capital and labour) in the model.

From the literature, there are a large number of potential variables that can affect the TFP in this case. However, due to data availability and following

Shahbaz and Lean (2011); Bashiru (2011); Oh and lee (2004a) and Stern (1999), the study examined the following variables of interest resulting in:

$$A = f(EC, FD, INF, D, M) = EC^{\beta_2} FD^{\beta_3} INF^{\beta_4} \mathrm{M}^{\beta_5} D^{\beta_6} \quad (2)$$

By substituting (2) into (1) and by specifying an extended Cobb-Douglas production function to represent the production technology of an economy, the study obtain;

$$Y_t = K_t^{\beta_1} EC_t^{\beta_2} FD_t^{\beta_3} INF_t^{\beta_4} LF_t^{\beta_5} \mathrm{M}^{\beta_6} \mathrm{D}^{\beta_7} \quad (3)$$

Where Y is real GDP, K is capital stock, EC is electricity consumption, FD is financial development, INF is inflation, LF is Labour force, M is a dummy variable for constitutional regime and D is a dummy variable for economic reform.By taking logarithm of the variables involved in equation (3) and differencing real GDP, the study estimated a log-linear growth model of the form

$$\Delta \ln Y_t = \beta_0 + \beta_1 \ln K_t + \beta_2 \ln EC_t + \beta_3 FD_t + \beta_4 INF + \beta_5 LF_t + \beta_6 M + \beta_7 D + \varepsilon_t \quad (4)$$

Where ln denotes natural logarithm, ΔY is the economic growth, *EC*, *K*, *FD*, *INF*, *LF*, *M* and D have already been defined. The coefficients $\beta_1, \beta_2, \beta_3, \beta_4, \beta_4, \beta_5$, β_6 and β_7 are the elasticities of the respective variables, β_0 is the drift components, t denotes time and ε is the error term.

A priori Expected Signs

The following are the a priori expected signs: $\beta_1 >0, \beta_2 >0, \beta_3 >0, \beta_4 <0$, $\beta_5 >0$, β_6 >0 and β_7 >0. The justification of the a priori expected signs and the measurement of the variable are clearly shown in the next page.

Justification and Measurement of Variables

Measuring Economic Growth (Y)

Economic growth refers to the steady growth in the productive capacity of an economy over a given period of time. Following from literature, changes in real gross domestic product is used as a measure for economic growth for this study (Wolde-Rufael, 2006; Esso, 2010; Bashiru, 2011; King & Levine, 1993). Gross domestic product (GDP) is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsides not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources (World Bank, 2011).

Many researchers use the GDP deflator and the consumer price index interchangeably to deflate the nominal GDP. The GDP deflator to some extent is considered to be more efficient than the CPI because the deflator considers both producer and consumer goods whereas the CPI only covers consumer goods and services. The deflator is therefore used to deflate the nominal GDP to obtain the real GDP for the study.

Measuring Electricity consumption

Electricity consumption measured in Kilo Watts per hour (KWh) is defined as the amount of electricity consumed by each country or region in the year specified. This variable includes electricity from all energy sources and its accounts for the amount of electricity consumed by the end user, meaning that losses due to transportation, friction, heat loss and other inefficiencies are not included in this figure. This variable has been used extensively in numerous works to measure electricity consumption (Adom, 2011; Akinlo, 2008; and Wolde-Rufael, 2006).

The role of electricity consumption has been widely recognized as a growth-enhancing factor in developing countries (Khan and Ahmed, 2009). The effects of electricity consumption in an economy are normally believed to augment productivity, increase in employment and also encourage access to new technologies. The study therefore expects the coefficient of electricity consumption to be positively related to economic growth ($\beta_2>0$).

Other variables in the model:

Financial development *(FD):*

Financial development is usually defined as a process that marks improvement in quantity, quality, and efficiency of financial intermediary services (Abu-Bader & Abu-Qarn, 2008). Generally, financial development (*FD)* entails increasing financial intermediation, raising pension funds, expanding bonds and equity markets and tapping international sources of capital. It is expected to stimulate economic growth by enlarging the services provided by financial intermediaries such as savings mobilisation, project evaluation, and risk management all things being equal.

Following from literature, the study used M2 as a percentage of GDP as a proxy for financial development. Money supply (M2) consists of M1 which comprises currency, that is, paper money and coins in the hands of the non-bank public, checkable deposits in commercial banks and other depository institutions plus savings and time deposits or quasi money. M2/GDP represents the ratio of money stock to Gross Domestic Product (GDP). It has been employed in most studies as the standard measure of financial development because it has been found to be a good one and in most cases data are readily available (King & Levine, 1993). A high M2/GDP is expected to promote economic growth, all things being equal. The study therefore expects $\beta_3 > 0$.

Macroeconomic Instability (inflation)

Inflation as measured by the consumer price index reflects how much the weighted price of a basket of consumer goods has changed over a given period of time. The study used this variable as an indicator to capture macroeconomic instability. The inflation rate indicates the overall ability of the government to manage the economy. A higher inflation rate implies that the government has lost control and this may have detrimental effect on the output of the economy.

Also, inflation may affect the real sector through the banking system by reducing the overall amount of credit available to businesses. Higher inflation reduces the real rate of return on assets which in turn discourages saving and subsequently impacts on economic growth negatively (Quartey, 2010). The study therefore expects this variable to be negatively related to growth ($\beta_4 < 0$).

Capital Stock *(K)*

Gross fixed capital formation (K) formerly gross domestic fixed investment includes plants, machinery and equipment. It also includes the construction of roads, railways, and others such as schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. The variable is used as a proxy for capital stock and is expected to exert a positive impact on real GDP. As mentioned in Barro, and Sala-i-Martin (1992), countries that invest more tend to grow faster than those countries that save and invest less. Some African countries like Ghana which had low growth rates accounted only for a small percent of investments in GDP. Meanwhile, in such Asian countries like the four Asian Tigers (South Korea, Singapore, Hong Kong and Taiwan) investments yielded up to 50 percent of GDP.

Consequently, the study expects the coefficient of capital to be positive ($\beta1>0$) on a priori and theoretical grounds, thus the higher the rate of investment, the higher the rate of real GDP growth, all things being equal. This is in line with both the neoclassical and endogenous growth predictions. Gross fixed capital formation as a proxy for capital has also been used in several other studies such as Aryeetey and Fosu (2005). It is also worth emphasizing that the capital used in the study refers to real capital calculated using 2000 constant prices.

Labour Force (LF)

For the labour input in this study, labour force which constitutes the percentage of the total population aged 15 to 65 years, who are active and economically productive and is expected to have a positive impact on growth is considered as an appropriate measure of labour input. The reason for choosing this variable is its authenticity in empirical literature on growth (Jayaraman and Singh, 2007) as there can be no growth achievement without the involvement of labour as a factor input. Solow (1956) and Swan (1956) also advised that labour force should be included in an endogenous growth model because of its impact on the work force and this has been proven empirically in many researches. All things being equal, the higher the labour force the higher the supply of labour and hence output. Therefore, the coefficient of labour is expected to be positive (β_5).

Constitutional Regime Variable (M*)*

The constitutional regime variable as a dummy variable is included to capture the impacts of constitutional rule that existed during the period under consideration. It is a binary variable which takes the value of zero for the period in which there was no constitutional regime and one for the period under constitutional rule. Thus, D=1 from 1971; 1980-1981; 1993-2010 and D=0 from 1972-1979; 1982-1992. A regime of constitutional rule ensures well functioning democratic institutions, which is a precondition for a favourable investment climate. Non-constitutional transfers of executive power (thus coups) are particularly likely to increase uncertainty (Stasavage, 2002). Thus, a socio-politically stable environment where property rights and contracts are enforced through a properly functioning judicial system will have a positive impact on private investment and hence economic growth. Hence, the coefficient of this dummy variable in the model is expected to be positive ($\beta_6 > 0$).

Economic Reform Variable (D)

The economic reform variable used in this study is constructed such that it takes the value of one (1) in periods after the reforms (1983-2010) and zero (0) otherwise. The variable is included in the model to discern the effect of economic reforms on economic growth. This variable is therefore expected to have a positive impact on GDP growth. Hence, the coefficient of this dummy variable is expected to be positive ($\beta_7 > 0$).

All variables are expressed as natural logarithms, with the exception of Financial development, Inflation and Labour force which were already in a preferred measure thus in percentages.

Data Type and Source

The study relies on secondary data. The data on all the variables were obtained from the World Development Indicators (WDI) online database. These data sets were crossed checked from various sources for consistency and were proved to be consistent with each order. The study considers a sample period of 40 annual observations for each variable ranging from 1971 to 2010.

Estimation Procedures

To test the direction of causality between electricity consumption and economic growth, the study applied Granger causality test within the framework of cointegration and error-correction models. The testing procedure involves:

1. First, testing the time series properties of the data by using the Augmented Dickey–Fuller (ADF) and the Phillip-Perron (PP) tests. This was done by carrying out the unit roots test to determine whether the variables are stationary.
2. Second, the study proceeds to test for short-run and long-run relationships among the variables using the Autoregressive Distributed Lag (ARDL) approach otherwise known as the bounds testing approach to cointegration.
3. Thirdly, the stability and diagnostic test statistics of the ARDL model is examined to ensure the reliability and the goodness of fit of the model.
4. Finally, the study employed Granger-causality to test for the causality relationship between electricity consumption and economic growth. The causality test is preceded by cointegration testing since the presence of cointegrated relationships have implications for the way in which causality testing is carried out.

Unit Roots Test

Confirming the order of integration is a pre-requisite for almost all time series analysis. Time series data are mostly non stationary in level forms and that regression involving non-stationary time series often lead to the problem of spurious regression. This occurs when the regression results reveal a high and statistically significant relationship among variables when in fact, no relationship exist. A time series is stationary if its mean, variance and autocovariances are independent of time but due to the data generating process, time series data is rarely stationary.

The study used both the Phillips-Perron (PP) and the Augmented Dickey-Fuller (ADF) statistic to test for the presence of unit roots tests. This was done to ensure reliable results of the test for stationarity due to the inherent individual weaknesses of the techniques. These tests are similar except that they differ with respect to the way they correct for autocorrelation in the residuals and also the ADF test is low power in small sample (Cheung and Lai, 1993), so the study applied the PP unit roots tests to check the robustness of the estimation results. The PP nonparametric test generalises the ADF procedure, allowing for less restrictive assumptions for the time series in question

The null hypothesis to be tested is that the variable under investigation has a unit roots against the stationarity alternative. In each case, the lag-length is chosen using the Akaike Information Criterion (AIC) and Schwarz Information Criterion (SIC) for both the ADF and PP test. Both the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) or Schwarz Information Criterion (SIC) have the common objective of selecting a model that produces errors that approach a white noise process as much as possible, subject to the constraint that the smallest possible number of lag terms or estimated parameters is included to ensure parsimony as well (Bashiru, 2011).

The sensitivity of ADF tests to lag selection renders the PP test an important additional tool for making inferences about unit roots. The basic formulation of the ADF is specified as follows:

$$\Delta X_t = \alpha + \delta t + \rho X_{t-1} + \sum_{i=1}^{P} \lambda_i \Delta X_{t-1} + \varepsilon_{1t} \qquad (5)$$

Where X_t denotes the series at time t, Δ is the first difference operator, α , δ , ρ , λ are parameters to be estimated and ε is the stochastic random disturbance term.

It is widely known that the ADF tests do not consider cases of heteroscedasticity and non-normality that are regularly disclosed in raw data of economic time series variables, and are also unable to discriminate between stationary and non stationary series that have a high degree of autocorrelation. The PP test for unit roots is therefore employed in the empirical analysis in order to resolve this problem. The PP test is also superior to the ADF test in situations where the time series variables under consideration have serial correlation and a structural break. This is based on the assumptions inherent in both tests. The ADF test assumes the error terms are independent with a constant variance whereas the PP test assumes the error terms are weakly dependent and heterogeneously distributed and thus provides robust estimates over the ADF and is specified as follows:

$$\Delta X_t = \alpha + \lambda_2 X_{t-1} + \theta\left(t - T/2\right) + \sum_{i=1}^{m} \theta_i \Delta_{t-i} + \varepsilon_{2t} \qquad (6)$$

In both equations (5) and (6), $\varepsilon_{1i}, \varepsilon_{2i}$ are the covariance stationary random error terms. The following hypotheses are therefore tested in both situations:

$$H_0 : \rho = 0$$

$$H_1 : \rho \neq 0$$

The null hypothesis is that the series contains unit roots, implying non stationary against the alternative hypothesis that it does not contain unit roots, implying stationary. The decision rule is that, if the ADF and PP statistics are higher (in absolute terms) than the critical values, we fail to accept the null hypothesis and conclude that there is no unit root implying stationary. Also, if the ADF and PP statistics are less negative than the critical values then we fail to reject the null hypothesis and conclude that there is unit root implying non stationary.

Autoregressive Distributed Lag (Bounds Test) Approach to Cointegration

A large number of past studies have used the Johansen cointegration technique to determine the long-term relationships between variables of interest. In fact, this remains the technique of choice for many researchers who argue that this is the most accurate method to apply for I(1) variables. Recently, however, a series of studies by Pesaran and Shin (1999), Pesaran and Pesaran (1997) and Pesaran et al. (2001) have introduced an alternative cointegration technique known as the 'Autoregressive Distributed Lag (ARDL)' bound test. This technique has a number of advantages over Johansen cointegration techniques. First, the ARDL model is the more statistically significant approach to determine the cointegration relation in small samples, while the Johansen co-integration techniques require large data samples for validity. In other words, the ARDL approach is more robust and performs better for small sample sizes (such as in this study) than other co-integration techniques (Pesaran & Shin, 1999).

A second advantage of the ARDL approach is that while other cointegration techniques require all of the regressors to be integrated of the same order; the ARDL approach can be applied whether the regressors are *I*(1) and/or *I*(0). This means that the ARDL approach avoids the pre-testing problems associated with standard cointegration, which requires that the variables be already classified into I(1) or I(0) (Pesaran et al., 2001). For instance, if we are not sure about the unit roots properties of the data, then applying the ARDL procedure is the more appropriate model for empirical work. As Bahmani-Oskooee (2004) explains, the first step in any cointegration technique is to determine the degree of integration of each variable in the model but this depends on which unit roots test one uses since different unit roots tests could lead to contradictory results. For example, applying conventional unit roots tests such as the Augmented Dickey Fuller and the Phillips-Perron tests, one may incorrectly conclude that a unit roots is present in a series that is actually stationary around a one-time structural break (Perron, 1991) The ARDL approach is useful because it avoids these problems.

Another difficulty of the Johansen cointegration technique which the ARDL approach avoids concerns the large number of choices which must be made: including decisions such as the number of endogenous and exogenous variables (if any) to be included, the treatment of deterministic elements, as well as the order of VAR and the optimal number of lags to be used. The estimation procedures are very sensitive to the method used to make these choices and decisions (Pesaran & Shin, 1999). Finally, with the ARDL approach it is possible that different variables have different optimal numbers of lags, while in Johansen-type models this is not permitted.

According to Pesaran and Pesaran (1997), the ARDL approach requires the following two steps. In the first step, the existence of any long-term relationship among the variables of interest is determined using an F-test. The second step of the analysis is to estimate the coefficients of the long-run relationship and determine their values, followed by the estimation of the short-run elasticity of the variables with the error correction representation of the ARDL model. By applying the ECM version of ARDL, the speed of adjustment to equilibrium will be determined.

In this study, following Pesaran et al. (2001) and Shahbaz and Lean (2011), the short run and long run elasticities are estimated by following the Unrestricted Error Correction Model (UECM) which has unrestricted intercepts and no trends based on the assumption made by Pesaran et al. (2001) as:

$$\Delta LnY_t = \beta_0 + \beta_1 \ln Y_{t-1} + \beta_2 \ln K_{t-1} + \beta_3 \ln EC_{t-1} + \beta_4 FD_{t-1} + \beta_5 INF_{t-1} + \beta_6 LF_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta lnY_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \ln K_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta \ln EC_{t-i} + \sum_{i=1}^{p} \alpha_{4i} \Delta FD_{t-i} + \sum_{i=1}^{p} \alpha_{5i} \Delta INF_{t-i} + \sum_{i=1}^{p} \alpha_{6i} \Delta LF_{t-i} + \upsilon_t \quad (7)$$

Where Δ denotes the first difference operator, ρ is the lag order selected by Akaike's Information Criterion (AIC), β_0 is the drift parameters while υ_t is white noise error term which is ~N (0, δ^2). The parameters α_{ij} are the short-run parameters and β_{ij} are the long-run multipliers. All the variables are defined as before.

The study begins by estimating equation (7) with the bounds test by applying the OLS method which is normally the first procedure in the ARDL model. The F-test or Wald test is used to test for the presence of long-run relationship among the variables in equations (7) given as follows: The null hypotheses of no long-run relationship among the variables in equations (7) is tested against the alternative hypotheses of a long- run relationship as follows:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$

H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$

The existence of cointegration between the variables under consideration is tested based on the F-statistics or Wald statistics. Given that the asymptotic distribution of F-statistics is non-standard without considering the independent variables being *I*(0) or *I* (1), Pesaran and Pesaran (1997) have provided two sets of critical values for the different numbers of regressors (k), and whether the ARDL model contains an intercept and/or trend. Therefore, the calculated *F*-statistic is compared with these sets of critical values developed on the basis that the independent variables are *I*(d) (where $0 \leq d \leq 1$).

The lower critical bound assumes that all the variables are I(0), meaning that there is no co-integration among the variables, while the upper bound assumes that all the variables are I(1). so if the calculated F- statistic falls outside the upper critical value, then a null hypothesis of no cointegration will be rejected regardless of whether the variables are I (0) or I (1) implying a long- run relationship among the variables.

However, if the *F*-statistic falls below the lower bound then the null hypothesis of no co-integration cannot be rejected. If the *F*-statistic lies within the lower critical and upper critical bounds, the test is inconclusive and its depends on whether the underlying variables are I(0) or I(1). This necessitates the testing for unit roots on the variables under investigation (Pesaran & Pesaran, 1997).

In order to obtain the optimal lag length for each variable, the ARDL methodology estimates $(m+1)^{k+1}$ number of regressions, where p is the maximum number of lags to be used and k is the number of variables in the equation. The lag of the ARDL model is based on the Schwarz-Bayesian Criterion (SBC) or the Akaike Information Criterion (AIC) or the Hannan and Quinn (*HQ*) criterion. The SBC uses the smallest possible lag length and is therefore described as the parsimonious model.

Given that cointegration has been established from the ARDL model, the long-run and error correction estimates of the ARDL and their asymptotic standard errors are then obtained.

$$\ln Y_t = \mu_0 + \sum_{i=1}^{p} \beta_1 \ln Y_{t-i} + \sum_{i=0}^{q_1} \beta_2 \ln EC_{t-i} + \sum_{i=0}^{q_2} \beta_3 \ln K_{t-i} + \sum_{i=0}^{q_3} \beta_4 FD_{t-i} + \sum_{i=0}^{q_4} \beta_5 INF_{t-i}$$
$$\sum_{i=0}^{q_5} \beta_6 LF_{t-i} + \lambda_1 M + \lambda_2 D + \nu_t \qquad (8)$$

The ARDL error correction representation of the series is also estimated as

$$\Delta \ln Y_t = \phi_0 + \sum_{i=1}^{p} \delta_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{p} \delta_{2i} \Delta \ln EC_{t-i} + \sum_{i=0}^{p} \delta_{3i} \Delta \ln K_{t-i} + \sum_{i=0}^{p} \delta_{4i} \Delta FD_{t-i}$$
$$+ \sum_{i=0}^{p} \delta_{5i} \Delta INF_{t-i} + \sum_{i=0}^{p} \delta_{6i} \Delta LF_{t-i} + \gamma ECT_{t-1} + \lambda_1 M + \lambda_2 D + \nu_t \quad (9)$$

Where γ is the speed of adjustment of the parameter to long-run equilibrium following a shock to the system and ECT_{t-1} is the residuals obtained from equations (8). The coefficient of the lagged error correction term γ is expected to be negative and statistically significant to further confirm the existence of a co-integrating relationship among the variables in the model.

The diagnostic test statistics of the selected ARDL model can then be examined from the short-run estimates at this stage of the estimation procedure to ensure the reliability of the goodness of fit of the model. The test for parameter stability can also be performed at this stage by plotting the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) to know whether the coefficients of the estimated model are stable over the study period.

Granger Causality Test

The study of causal relationships among economic variables has been one of the main objectives of empirical econometrics. According to Engle and Granger (1987), cointegrated variables must have an error correction representation. One of the implications of Granger representation theorem is that if non-stationary series are cointegrated, then one of the series must Granger cause the other. This statement of causality means that X_t causes Y_t if the past history of X_t can be used to predict Y_t more accurately than simply using the past history of Y_t only. Y is said to be Granger-caused by X if X helps in the prediction of Y, or equivalently if the coefficients of the lagged X's are statistically significant. It is important to note that the statement 'X Granger causes Y' does not imply that Y is the impact or the result of X.

Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term. This type of is causality is importantly for at least two reasons. First, it is equivalent to the econometric exogeneity in the sense that unidirectional causality that runs from the explanatory variables to the dependent variables serves a prerequisite for the consistent estimation of distributed lag models that do not involve lagged dependent variables.

Second, it can be likened to leading indicators and rational expectations. To examine the direction of causality in the presence of cointegrating vectors, Granger causality is conducted based on estimating:

$$X_t = \sum_{i=1}^{\infty} \alpha_i Y_{t-i} + \sum_{i=1}^{\infty} \beta_i X_{t-i} + \mu_t \quad (9)$$

$$Y_t = \sum_{i=1}^{\infty} \lambda_i X_{t-i} + \sum_{i=1}^{\infty} \lambda_i Y_{t-i} + \eta_t \quad (10)$$

Where $\alpha_i = (i = 1, 2, ..., \infty)$ so that Y_t fails to cause X_t. The error terms are assumed to fulfill the criteria E(μ_t)= E(η_t)= E($\mu_t \mu_s$)= E($\mu_t \mu_s$)=0; and E($\mu_t \mu_t$)= δ_μ^2 , E($\eta_t \eta_t$) = δ_η^2.

Data Analysis

The study employed both descriptive and quantitative analysis. Charts such as graphs and tables were employed to aid in the descriptive analysis. Unit roots tests were carried out on all variables under the study to ascertain their order of integration. Furthermore, the study adopted the Autoregressive Distributed Lag (ARDL) econometric methodology for co-integration to obtain both the short and long run estimates of the main variables involved. All estimations were carried out using Microfit (4.1) and Econometric views (Eviews) 5.0 package.

Conclusion

This chapter formulated the econometric model to be estimated for the study and specified the technique to be used for estimation. The methodology of this study was developed from an endogenous growth model in which electricity consumption, real GDP per capita, financial development, capital stock, inflation and labour force are the main variables of interest. Explanations of the various tests of stationarity that was adopted for this study were also shown.

The study further described the sources and data set used in carrying out the study and also described the variables used in the research. The ARDL approach to co-integration and error correction models are used to determine the adjustment to equilibrium among the key variables. The study finally formulates the Granger causality equations to determine the direction of causality of the variables under investigation.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The results of the study are presented and discussed in this chapter. The results of the descriptive statistics of the relevant variables, both ADF and PP unit roots tests, Bounds test approach to cointegration, Granger-causality test, and stability and diagnostics tests are presented and discussed. These results are discussed in relation to the hypotheses of the study.

Descriptive Statistics

In this section, an analysis of the descriptive statistics is carried out. Table 1 illustrates these statistics. From Table 1, the total number of observations used was 40 and it was found that all the variables have positive means. Further examination of the table reveals that all the variables are slightly positive skewed with the exception of electricity consumption meaning that extreme changes of the series were not recorded within the observed period. The deviation of the variables from their means as shown by the standard deviation gives indication of wide growth rate (fluctuation) of these variables over the study period.

The Jarque-Bera statistic also shows that the null hypothesis that the series are drawn from a normally distributed random process can be rejected for all the variables since their probability values are not statistically significant with the exception of electricity consumption, capital stock and inflation. The probability values of these variables (electricity consumption, capital stock and inflation) are significant as shown in Table 1 below.

Table 1: Summary Statistics

	LY	LEC	LK	FD	INF	LF
Mean	6.54442	22.2220	2.93852	19.3763	33.1699	53.6532
Median	6.52206	22.2605	2.99353	19.5533	28.1735	53.0920
Maximum	6.89936	22.6587	3.88778	29.4938	123.061	57.6005
Minimum	6.25225	20.8639	1.20546	9.68406	5.18907	51.1832
Std. Dev.	0.15802	0.37277	0.62683	5.55543	22.9398	2.22448
Skewness	0.31840	-1.5857	0.82271	0.06186	2.00282	0.43951
Kurtosis	2.48593	6.10375	3.35118	2.18352	7.55684	1.71230
Jarque-Bera	1.11631	32.8202	4.71790	1.13659	61.3499	4.05138
Probability	0.57227	0.00000	0.09452	0.56649	0.00000	0.13190
Sum	261.777	888.881	117.541	775.053	1326.80	2146.13
Sum Sq. Dev.	0.9738	5.41927	15.3239	1203.65	20523.1	192.985
Observations	40	40	40	40	40	40

Note: Std. Dev. represents Standard Deviation while Sum Sq. Dev. represents Sum of Squared Deviation

Source: Computed by the author using Eviews 5.0 Package

Stationary Test

Before applying the ARDL or bounds test approach to cointegration and Granger-causality test, unit roots test was first conducted in order to investigate the stationarity properties of the data series. This was done to ensure that the variables were not integrated of order two (that is, I(2)) so as to avoid spurious results. The computed F-statistics provided by Pesaran et al. (2001) are not valid in the presence of I(2) variables. This is so because the bounds test is based on the assumption that the variables are integrated of order zero (that is, I(0)) or integrated of order one (that is, I(1)). As a result, all the variables were examined by first inspecting their trends graphically (Appendix A). From the graphs in Appendix A and B, it is clear that all the variables except inflation rate appear to exhibit behaviours of non-stationary series. However, the first differences of the variables show no trend indicating that the series are stationary in their first difference.

Additionally, the Augmented Dickey-Fuller (ADF) and Phillips and Perron (PP) tests were applied to all variables in levels and in first difference in order to formally establish their order of integration. The optimal number of lags included in the test was based on automatic selection by Schwarz-Bayesian Criterion (SBC) and Akaike Information Criterion (AIC). The study presented and used the P-values for making the unit roots decision which arrived at similar conclusion with the critical values. In order to be sure of the order of integration of the variables, the test was conducted first with intercept and no time trend and second with intercept and time trend. The results of both tests for unit roots for all the variables at their levels with intercept and trend and their first difference are presented in the Appendix.

Appendices C, D, E and F show that at levels, the null hypothesis of the presence of unit roots for all the variables with the exception of inflation rate cannot be rejected since the P-values of the ADF and the PP statistic are not significant at all the conventional levels of significance. However, at first difference, all the variables are stationary since the unit roots hypothesis could be rejected for all the variables. The results show that real GDP per capita, electricity consumption measured in kilo watts per hour, capital stock, labour force and financial development are each integrated of order one or I (1) while inflation is integrated of order zero or I (0) according to both the ADF and PP statistics. Therefore, in order to eliminate the possibility of spurious regression results, the first difference of the variables was employed in the estimation process.

Cointegration Analysis

Johansen (1991) argued that cointegration can be used to establish whether there exists a linear long-term economic relationship among the variables of interest. Therefore, since the aim of this study is to examine the relationship between electricity consumption and economic growth, it is essential to test for the existence of long-run equilibrium relationships between the variables within the framework of the bounds testing approach to cointegration. Given a small sample size and the use of annual data, a lag length of 2 is used in the bounds test.

Pesaran and Shin (1996) suggested a maximum lag length of 2 for annual data in the bounds test approach.

The initial step of the ARDL approach is to estimate the conditional UECM model by ordinary least square in order to test for the presence of long run relationship among the variables. This is done by conducting an F-test for the joint significance of the coefficients of the lagged level variables in the model. Thus, each of the variables in the model is taken as a dependent variable and a regression is run on the others. For instance, real GDP per capital is taken as the dependent variable and it is regressed on the other variables. After that another variable for example, electricity consumption in the model is also taken as the dependent variable and it is regressed on the other variables. This action is repeated for all the variables in the model and when this is done the number of estimated regressions would be equal to the number of variables in the model.

According to Pesaran et al (1997), these OLS regressions in the first differences are of no direct interest to the bounds cointegration test. It is however, the F-statistic values of all the regressions when each of the variables is normalized on the others which are of great importance. This F-statistic tests the joint null hypothesis that the coefficients of the lagged levels are zero thus indicating whether there is the existence or otherwise cointegration among the variables in the long run.

Table 2 reports the results of the computed F-statistic when each variable is normalized (that is, considered as a dependent variable) in the ARDL–OLS regressions.

Table 2: Bounds Test for the existence of Cointegration

	90% level		95% level		99% level	
K	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
5	2.262	3.367	2.649	3.805	3.516	4.781

Dependent Variable	F- Statistic
$F_{LY}(LY \mid LEC,FD,LK,INF,L)$	3.7403
$F_{LEC}(LEC \mid LY,FD,LK,INF,LF)$	1.3544
$F_{FD}(FD \mid LY,LEC,LK,INF,LF)$	2.1454
$F_{LK}(LK \mid LY,LEC,FD,INF,LF)$	3.4579
$F_{INF}(INF \mid LY,LEC,LK,FD,LF)$	1.5874
$F_{LF}(L \mid LY,LEC,LK,FD,INF)$	2.1378

Note: Critical values are obtained from Pesaran and Persaran (1997), Appendix C, Table F, pp. 478 and K is the number of regressors in equations (7).

Source: Computed by the author using Microfit 4.1

From Table 2, the calculated F-statistic reported shows that, there exists a long-run relationship between economic growth (Y) and its explanatory variables because the F-statistic value of 3.7403 is higher than the top critical bound value of 3.367 at 10 percent significance level. This implies that the null hypothesis of no cointegration among the variables in equation (7) is rejected meaning that there exists a long run relationship between economic growth and its determinant in equation (7).

Again Table 2 show that when the other variables are taken as dependent variable, the calculated F- statistic values are less than the lower bound critical values, thus accepting the null hypothesis of no cointegration. However, capital stock is cointegrated when used as dependent variable at 10 percent significant levels. This is because the calculated F- statistic value of F_{LK} (.) = 3.4579 exceed the upper critical value of 3.367 at 90% significance level as shown in Table 2.

These results mean that the null hypothesis of no cointegration cannot be rejected when electricity consumption, financial development, inflation and labour force are used as dependent variable. This is because their calculated F-statistic values of 1.3544, 2.1454, 1.5874 and 2.1378 respectively are less than the lower critical bound value of 2.262 at 10 percent level of significance.

Since ARDL framework is a single equation model and this study is based on growth theory, economic growth variable (LY) is used as the dependent and consequently the result of the other regression that is cointegrated is neglected. Given that there is existence of cointegration among the variables in the growth equation, the study therefore proceeds with the growth equation to estimate their long run coefficients and the short-run dynamic relationships using the ARDL cointegration framework.

Results of the Long-Run Relationship

Given the results of the cointegration analysis, the long run relationships among the variables were estimated using the ARDL framework and the results are presented in Table 3. The Schwarz-Bayesian Criterion (SBC) and a lag length of two was used in the estimation of the ARDL model, given the annual nature of the data set.

As shown in Table 3, the results indicate theoretically correct and a prior expected signs for all of the explanatory variables. Electricity consumption measured in kilo watts per hour (KWh), financial development, capital stock, inflation, the dummy variable for constitutional regime and labour force all have the expected sign and exert statistically significant effect on real GDP (Y) in the long-run. The constant term is also positive and statistically significant

Table 3: Long-run estimates based on ARDL Approach

Variable	Coefficient	Standard error	T-Ratio	[Prob.]
LEC	0.11372	0.030283	3.7553	[0.001] ***
FD	0.0088897	0.0037047	2.3996	[0.024] **
LK	0.14987	0.049333	3.0379	[0.005] ***
INF	-0.0026229	0.0008028	-3.2673	[0.003] ***
LF	1.1483	0.22450	5.1150	[0.000] ***
M	0.073902	0.027269	2.7101	[0.012] **
D	0.32404	0.87267	0.3713	[0.713]
C	11.4785	5.6615	2.0274	[0.052] *

Note: ***,**, and * denote significance at 1%, 5% and 10% respectively

Source: Computed by the author using Microfit 4.1

Holding the influence of all the variables in the model constant, the positive and statistically significant constant term in Table 3 implies that the Ghanaian economy will grow by approximately 11.5 percent due to the influence of all other variables that are not included in the model.

From Table 3, the long-run relationship results confirm the a priori expectation that electricity consumption contributes positively to growth of GDP since the coefficient of the electricity consumption in the long run growth equation is positive and statistically significant at 1 percent level. The coefficient of 0.11372 indicates that a 1 percent change in electricity consumption results in approximately 0.114 percent change in real GDP.

This means that in the long-run, a 1 percent increase in electricity demand has the potential of stimulating economic growth in Ghana by about 0.114 percent. This result is in line with what Khan and Ahmed (2007) asserted for developing countries that increases in electricity consumption influences economic growth by augmenting productivity, increasing employment and also encouraging access to new technologies. The positive relationship between electricity consumption and economic growth concurs with the findings of Odhiambo, (2009) for Tanzania and Belloumi (2009) for Tunisia who found a positive long run relationship between electricity consumption and economic growth.

Consistent with expectation, the coefficient of financial development is positive and statistically significant at 5 percent. The result specifically shows that, in the long run, if the country deepens the financial sector by 1 percent, there will be a 0.0088897 percent increase in real GDP. The positive and statistically significant effect of the financial development is consistent with the predictions of the endogenous growth theorists as well as the supply leading view of the relationship between financial development and economic growth.

Both the McKinnon-Shaw and the Endogenous growth theorists predict that financial deepening affects growth through investment. The endogenous growth theory emphasizes the role of the financial sector in promoting innovations, income distribution and the speed of technological progress, thus contributing to long-term economic growth (King & Levine, 1993). Consistent with the endogenous growth theory, the financial sector promotes long-run economic growth through two major channels: the volume of investment and the efficiency of investment. This result concurs with the findings of Quartey and Prah (2008) in Ghana but contradict the findings by Esso (2010) and Ahmed (2008) for Sierra Leone. Ahmed (2008) found negative but significant relationship for Sierra Leone when private sector credit was used to measure financial development. The findings by Esso (2010) showed negative impact of financial development on real GDP in the long-run.

The results in Table 3 also confirms the a priori expectation that gross fixed capital formation to GDP (K) contributes positively to growth of GDP since the coefficient of capital in the long run growth equation is positive and statistically significant. The coefficient of 0.14987 indicates that a 1 percent change in capital input results in a 0.150 percent change in real GDP per capita. This means that in the long-run, a 1 percent increase in investment in physical capital has the potential of stimulating economic growth in Ghana by about 0.150 percent. Its statistical significance is shown by the p- value. This result is consistent with conclusions by Aryeetey and Fosu (2005) who obtained a positive relationship between capital and real GDP for Ghana.

As anticipated, inflation which is used to capture macroeconomic instability is appropriately signed. That is, the coefficient of inflation is significantly negative at 5 percent significance level. Thus the results indicate that, if the general price level increases by 1 percent, economic growth will significantly fall by 0.0026229 percent. This shows that stability of a country is an important element for achieving economic growth. The significant coefficient of the inflation variable means that if LDCs are streamlining their investment regulatory framework, implementing policies that will promote macroeconomic stability, can help achieve a higher level of economic growth (Asiedu, 2006).

The negative and statistically significant effect of inflation on economic growth in the long-run is consistent with the results obtain by Bittencourt (2010) for four Latin American Countries (Argentina, Bolivia, Brazil and Peru) that inflation has a negative effect on economic growth. Ahmed and Mortaza (2005) also found a statistically significant long-run negative relationship between inflation and economic growth for Bangladesh.

The results however contradict the findings by Erbaykal and Okuyan (2008). The findings by Erbaykal and Okuyan (2008) showed no statistically significant long-run relationship between inflation and economic growth for Turkey but however found a negative and statistically significant short-run relationship between inflation and economic growth.

The result in Table 3 also shows that the increase in the labour force is significant to the growth of the Ghanaian economy. This is consistent with the argument of Jayaraman and Singh (2007) who asserted that there can be no growth achievement without the involvement of labour as a factor input. The results specifically show that, in the long run, if labour force increase by 1 percent, there will be a 1.1483 percent increase in economic growth and this is statistically significant at 1 percent significant level.

Also, consistent with expectation, the dummy variable measuring constitutional regime is positive and statistically significant at 5 percent. Specifically, the coefficient of 0.073902 indicates that a 1 percent change in capital input results in a 0.074 percent change in real GDP. This suggests that sustained improvement in economic activities is a stimulant for private investment and consequently economic growth. This finding corroborates those found by Stasavage (2002) where major constitutional change was found to stimulate the flow of private investment and consequently economic growth

Finally, even though the coefficient of the dummy variable for economic reform is positive in the long run as expected, it is not statistically significant. The positive coefficient is an indication that further reform in the Ghana is likely to promote economic growth in Ghana.

The error correction model that calculates the error correction term for the adjustment to short run equilibrium when there is any disequilibrium in the system as a result of a shock is given as:

$$ECM = LY - 0.11372*LEC - 0.14987*LK - 1.1483*LF + 0.0026229*INF - 0.0088897*FD - 0.073902*M - 0.32404*D - 11.4785*C$$

Results of the Short Run Dynamic Model

Once the long run relationships among the variables have been established within the ARDL framework, the study further estimates their short run relationships. According to Engle and Granger (1987), when variables are cointegrated, their dynamic relationship can be specified by an error correction representation in which an error correction term (ECT) computed from the long-run equation must be incorporated in order to capture both the short-run and long-run relationships.

The error correction term indicates the speed of adjustment to restore equilibrium in the dynamic model. The ECM coefficient shows how quick the variables converge to equilibrium following a shock and it should have a statistically significant coefficient with a negative sign. According to Bannerjee, Dolado and Mestre (1998), the highly significant error correction term further confirms the existence of a long-run relationship. Table 5 shows the estimated short-run error correction model using the ARDL approach.

From the results, the coefficient of the lagged error correction term ECM lagged one period (ECM_{t-1}) is negative and highly significant at 1 percent significance level. This confirms the existence of the cointegration relationship among the variables in the model yet again. The ECM stands for the rate of adjustment to restore equilibrium in the dynamic model following a disturbance. The coefficient of the error correction term is 0.63359. This means that the deviation from the long-term growth rate in GDP is corrected by approximately 63 percent each year due to adjustment from the short-run towards the long-run. In other words, the highly significant error correction term suggests that more than 63 percent of disequilibrium in the previous year is corrected in the current year. The rule of thumb is that, the larger the error correction coefficient (in absolute terms), the faster the variables equilibrate in the long-run when shocked (Acheampong, 2007). Therefore, the result shows that the speed of adjustment is relatively high in the model.

Table 4: Estimated Short-Run ECM using the ARDL (1,0,0,0,1,0,1,0)

Regressor	Coefficient	Standard Error	T-Ratio	[Prob]
DLEC	0.072052	0.026569	2.7119	[0.011] **
DFD	0.0056324	0.0017389	3.2391	[0.003] ***
DLK	0.094956	0.024931	3.8087	[0.001] ***
DINF	-0.0004274	0.0002230	-1.9162	[0.066] **
DLF	0.076396	0.0092368	8.2708	[0.000] ***
M	0.046823	.019057	2.4570	[0.020] **
D	0.20531	0.53856	0.3812	[0.706]
C	4.5174	1.6724	2.7011	[0.011] **
DECM(-1)	-0.63359	0.14646	-4.3261	[0.000] ***

Note: *** and ** denote significance at 1% and 5% respectively.

Source: Computed by the author using Microfit 4.1

As shown in Table 4, the coefficient of the electricity consumption in the dynamic short run growth equation is positive and is statistically significant at 5 percent level of significance. This is consistent with the result of the long-run growth equation. From the results, a 1 percentage increase in electricity consumption will induce economic growth by approximately 0.072 percent in the short run. This result indicates the crucial role that electricity plays in Ghana's growth process as its coefficient is positive in the dynamic short run growth model just as in the long run model.

Again, the result in Table 4 shows that financial development positively affects economic growth in the short run just as in the long run. Specifically, economic growth will increase by 0.0056324 percent, should the financial sector be deepened by 1 percent. This is also significant at 1 percent level of significance. This result presuppose the need to develop the financial sector to promote loans, encourage interest rates reduction since this will have beneficial effect on investment, which would eventually foster economic growth.

Similarly, consistent with the long-run estimate, the coefficient of labour force maintained its positive sign and is statistically significant at 1 percent significant level. The results indicate that a 1 percent increase in labour force will increase economic growth by about 0.076396 in the short run. The positive effect of labour force is probably due to the international connections between Ghana and a host of countries such as England, China, Nigeria and others who imparted new skills and knowhow to the country labour force.

Additionally, the coefficient of capital variable (K) also maintained the positive sign consistent with the long run results. Specifically, the results confirm the theoretical conclusion that capital contributes to growth of GDP since the coefficient of capital in the short run growth equation is positive and significant at 1 percent level. This reaffirms the significant role of capital in the growth process of Ghana as its coefficient is positive both in the short run and the long run. From the results, the coefficient of capital is 0.094956 which indicates that a percent increase in capital input results in approximately 0.095 percent increase in economic growth, ceteris paribus. Again, this result is consistent with the results obtained by Aryeetey and Fosu (2005) for Ghana.

The coefficient of inflation in the short run is also negative, consistent with the long run findings. The results thus suggest that if inflation goes up by 1 percent, economic growth falls by 0.0004274 percent. The results indicate how important it is to control inflation in the Ghanaian economy by putting in the appropriate policies. Its impact both in the short and long run appears to be debilitating. The negative relationship between inflation and economic growth as revealed in this study again is in line with empirical findings by Stockman (1981) who argued that individuals' welfare falls whenever there is an increase in inflation.

Furthermore, a relatively stable socio-political environment is relevant for accelerated growth in the Ghanaian economy. This is reflected in the positive impact of the dummy variable proxying the periods of constitutional regimes. From the results, economic growth will increase by 0.046823 if the stable political climate improves by 1 unit. This finding suggests that sustained political climate is a stimulant for private investment and consequently economic growth.

Finally, consistent with the long run, the dummy variable measuring economic reform came out with a positive sign although it is not statistically significant.

Model Diagnostics and Stability Tests

Hansen (1992) warned that estimated parameters of a time series data may vary over time. As a result, it is essential therefore to conduct parameter tests since model misspecification may arise as a result of unstable parameters and thus has the tendency of biasing the results. In order to check for the estimated variable in the ARDL model, the significance of the variables and other diagnostic and structural stability tests of the model are considered. Table 5 shows the results for the model Diagnostics and Goodness of Fit.

Table 5: Model Diagnostics and Goodness of Fit

R-Squared (R^2)	0.75140	R-Bar-Squared	0.65933
S.E. of Regression	0.026477	F-stat. F(9, 28)	10.2012[.000]
Mean of Dependent Var.	0.006042	S.D. of Dependent Var	.045364
Residual Sum of Squares	0.018928	Equation Log-likelihood	90.5693
Akaike Info. Criterion	79.5693	Schwarz Bayesian Crit.	70.5625
DW-statistic	2.1032		

Diagnostics		**LM Version**	**F Version**
Serial Correlation	$\chi 2_{Auto}$ (1)	1.5249[.217]	91977[.348]
Functional Form	$\chi 2_{Reset}$ (1)	.18930[.664]	.11014[.743]
Normality	$\chi 2_{Norm}$ (2)	3.0777[.215]	
Hetero	$\chi 2_{white}$ (1)	1.8177[.178]	1.8085[.187]

Note: $\chi 2_{Auto}$ (1), $\chi 2_{Reset}$ (1), $\chi 2_{Norm}$ (2) and $\chi 2_{white}$ (1) are Lagrange multiplier statistics for test of serial correlation, functional form misspecification, non-normal errors and heteroskedasticity, respectively.

Sources: Computed by the author using Microfit 4.1

The diagnostic test in Table 5 shows that there is no evidence of autocorrelation and the test proved that the error is normally distributed. Additionally, the model passes the white test for heteroskedasticity as well as the RESET test for correct specification of the model. A DW-statistic of 2.1032 indicates that there is no strong serial correlation in the residuals. The overall regression is also significant at 1 percent as can be seen from the R-squared and the F-statistic in Table 5 above. The R-squared value of 0.75140 indicates that about 75 percent of the change in the dependent variable (LY) is explained by changes in the independent variables. Also, an F-statistic value of 10.2012 suggests the joint significance of the determinants in the ECM.

Finally, Pesaran and Pesaran (1997) advise that we employ the CUSUM and CUSUMSQ tests when analyzing the stability of the long-run coefficients together with the short-run dynamics. The constancy of the regression coefficients is evaluated by this stability tests and they can show whether or not the regression equation is constant over time. This stability test is suitable in time series data, especially when we are uncertain about when structural change might have taken place.

The null hypothesis is that the coefficient vector is the same in every period and the alternative is simply that it is not (Bahmani-Oskooee, 2004). CUSUM and CUSUMQ statistics are plotted against the critical bound of 5% significance. According to Bahmani-Oskooee (2004), if the plot of these statistics remains within the critical bound of the 5% significance level, the null hypothesis that all coefficients in the model are stable cannot be rejected. The plots of the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) stability tests as depicted in Appendix G and H indicate that all the coefficients of the estimated model are stable over the study period since they are within the 5 percent critical bounds.

Granger Causality Test

To find out the direction of causality between economic growth and electricity consumption, the study conducts a Granger causality test and the results are presented in Table 6.

Table 6: Pairwise Granger Causality Tests

Null Hypothesis	F- Stat	Prob.	Remarks
LEC does not Granger Cause LY	0.23661	0.79063	Cannot reject the null
LY does not Granger Cause LEC	7.95165	0.00152***	Null is rejected
FD does not Granger Cause LY	1.30798	0.06211*	Null is rejected
LY does not Granger Cause FD	3.02656	0.28402	Cannot reject the null
LK does not Granger Cause LY	3.41439	0.04490**	Null is rejected
LY does not Granger Cause LK	1.34503	0.27444	Cannot reject the null
INF does not Granger Cause LY	2.47882	0.09932*	Cannot reject the null
LY does not Granger Cause INF	5.19369	0.01094**	Null is rejected
LF does not Granger Cause LY	10.9112	0.00023***	Null is rejected
LY does not Granger Cause LF	2.77188	0.07713*	Null is rejected

Note: ***, **, and * denote significance at 1%, 5%, and 10% respectively

Source: Computed by the author using Microfit 4.1

The Granger causality test results in Table 6 suggests that the null hypothesis of electricity consumption does not Granger cause real GDP is not rejected, implying electricity consumption does not Granger cause real GDP. However, the null hypothesis that real GDP does not Granger cause electricity consumption is rejected, implying real GDP Granger causes electricity consumption. This means that there exists a unidirectional causality running from real GDP to electricity consumption. This result indicates that data on Ghana supports the Growth-led–Electricity hypothesis.

The unidirectional causality running from economic growth to electricity consumption as identified in this study is not in conformity with the Bounds tests results, as the bounds test result shows there is positive and statistically significant relationship between electricity consumption and economic growth. The reason behind this may probably due to differences in estimation techniques in both the Bounds tests and the Pairwise Granger Causality and also due to the small sample size of the study. However, this finding in line with the findings of Wolde-Rufael (2006); Twerefo et al (2008) and Adom (2011) but contradicts the conclusions reached by Lee (2005) and Akinlo (2008). Lee (2005) results indicate that there is unidirectional causality between electricity consumption and economic growth and it runs from electricity consumption to economic growth while Akinlo (2008) revealed bidirectional causality between electricity consumption and economic growth for Ghana in his panel study.

Similarly, the Granger causality test results in Table 6 suggests that the null hypothesis of financial development does not Granger cause real GDP is rejected at 10 percent significant level, implying financial development does indeed Granger cause real GDP. However, the null hypothesis that real GDP does not Granger cause financial development is not rejected, implying real GDP Granger does not causes financial development. This shows that there is unidirectional causality running from financial development to economic growth.

Furthermore, it can be observed from Table 6 that the null hypothesis that labour force does not Granger causes economic growth is rejected at 1 percent significance, also the null hypothesis that economic growth Granger causes labour force is rejected at 5 percent level of significance. This indicates that there is bi-directional causality between labour force and economic growth at 1 percent and 5 percent significance level respectively.

Similarly, the results from Table 6 indicate that Gross fixed capital formation Granger causes economic growth since the study fails to reject the null hypothesis of no Granger causality at the 5 percent significance level. This means that there is unidirectional causality running from Gross fixed capital formation Granger to economic growth.

Finally, the pair-wise Granger Causality tests showed a bi-directional causality between inflation and economic growth at 10 and 5 percent significance level respectively

Conclusion

This chapter of the study looked at the empirical results of the relationship between electricity consumption and economic growth. The chapter began by examining the time series properties of the data used for the estimation. The unit roots test employing both the ADF and the PP techniques basically showed that all the series had to be differenced once to achieve stationarity except for inflation that is stationary at levels. The study further conducted the test for cointegration using the Autoregressive Distributed Lagged Model (ARDL) and Granger causality test. The results disclosed a long-run cointegrating relationship between electricity consumption and economic growth in Ghana.

Both the short and long run estimates reveal a positive and statistically significant effect of electricity consumption on economic growth. This indicates the crucial role that electricity plays in Ghana's growth process as its coefficient is positive in the dynamic short run growth model just as in the long run model. The coefficient of ECM (1) is 0.63359. This means that the deviation from the long-term growth rate in GDP is corrected by 63 percent each year due to adjustment from the short run towards the long-run.

The diagnostic and parameter stability tests reveal that the model passes the tests of serial correlation, functional form misspecification, non normal errors and heteroscedasticity. The overall regression is also significant at both 5% and 1% as can be seen from the R-squared and the F-statistic and the graphs of the CUSUM and CUSUMSQ indicate the absence of any instability of the coefficients because the plots of these graphs are confined within the 5 percent critical bounds of parameter stability suggesting that all the coefficients of the estimated ARDL model are stable over the study period.

Finally, the Granger causality test result revealed that there is a unidirectional causality running from economic growth to electricity consumption. This result confirms that data on Ghana supports the Growth-led–Electricity hypothesis.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter summarizes the entire study. It presents summary, conclusions and recommendations derived from the analysis of the data collected. The chapter also presents the limitations and suggestions for further research.

Summary of the Study

Understanding the causality between electricity consumption and economic growth has been a challenge to those in the fields of growth and energy economics. Several researchers have tried to formulate models and undertake empirical works that could help in deepening the understanding of the relationships therein. But the global climate crises came as a wakeup call for all those in these fields to work harder for a better understanding of this causality.

The study set itself to meet three objectives. First, to examine both the long-run and short-run relationships between electricity consumption and economic growth in Ghana and most importantly to identify the causal relationship between electricity consumption and economic growth as well as the direction of causality.

To examine the long-run relationship and short-run dynamic parameters of the model, the Autoregressive Distributed Lagged Model (otherwise known as the bounds testing) approach to cointegration was employed. The data series –Real GDP per capita (LY), electricity consumption (LEC), financial development (FD), capital stock (K), labour force (L) and the policy variable, inflation (INF) were first subjected to ADF and PP tests in order to ascertain their stationarity properties. The ADF and PP tests revealed that all variables except inflation were integrated of order one. The study then proceeded to examine the long-run and short-run relationships between electricity consumption and economic growth. The findings of the study are therefore presented below:

1. The cointegration analysis revealed that there exist a positive and significant relationship between GDP growth and electricity consumption in the long run. The results of the long run growth equation revealed that a 1 percent increase in electricity consumption leads to approximately 0.11% increase in GDP growth. Consistent with the long-run results, the coefficient of electricity consumption in the short-run was also positive.
2. The study also found a positive and statistically significant relationship between capital stock and GDP growth both in the long run and short run. This reemphasizes the significant role that capital plays in the growth process of Ghana.
3. Furthermore, the result of the study revealed a positive and statistically significant relationship between GDP growth and labour force both in the long run and the short run. This is consistent with the argument of

Jayaraman and Singh (2007) who asserted that there cannot be growth achievement without the involvement of labour as a factor input.

4. In addition to the above, financial development registered a positive impact on economic growth in the short as well as the long run. This confirms the importance of deregulating the financial sector which may reduce credit rationing to firms and consequently improves economic growth through increases in investment.
5. As anticipated, the bounds tests results also revealed that inflation both in the long and short run exerted a statistically significant negative effect on economic growth. The negative and statistically significant impact of inflation on economic growth is in line with the traditional neoclassical theory as posited by Stockman. This is an indication that high inflation episode is unattractive to economic growth in Ghana.
6. Moreover, consistent with expectation, the dummy variable measuring constitutional regime came out with a positive sign and is statistically significant both in the short run and the long run. This means that a well functioning democratic system where property rights are protected, civil society, the judiciary among other state and institutions are adequately resourced and monitored could provide a vital bridge for growth in Ghana. The coefficient of the dummy variable suggests that sustained political climate is a stimulant for private investment and consequently economic growth.

7. The coefficient of the dummy variable measuring economic reforms was also positive as expected, but statistically insignificant indicating that further reform is necessary to ensure growth in the Ghanaian economy.
8. Again, the coefficient of the lagged error correction term is negative and statistically significant as expected at the 1 percent significance level, suggesting that it would not take a long time for the system to return to its equilibrium once it is out of equilibrium. The size of the coefficient on the error correction term (ECM) denotes that about 63.3 percent of the disequilibrium caused by previous years' shocks converges back to the long-run equilibrium in the current year.
9. The diagnostic tests results show that the model passes the test of serial correlation, functional form misspecification, non normal errors and heteroscedasticity. The graphs of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) exhibit that there exists a stable relationship between electricity consumption and economic growth over the study period.
10. Finally, investigation of the direction of causation among the variables using the Pairwise Granger causality testing procedure was utilized. The aim was to identify any causal relationship between electricity consumption and economic growth and in which direction. The result showed a unidirectional relationship between electricity consumption and

economic growth and it runs from economic growth to electricity consumption.

Conclusions

Based on the finding of the study, the following conclusions were reached:

1. From the results, the objective of investigating the relationship between electricity consumption and economic growth was accomplished. When considering short run and long impacts, electricity consumption was found to be a stimulus for economic growth of Ghana in the short and long run. These findings reveal that there are benefits from electricity consumption as reveal in the literature.
2. Secondly, in line with empirical evidence, capital stock, labour force and financial development all serve as important determinants on economic growth in Ghana. This finding implies that capital stock, labour force, and financial development are critical in achieving sustained economic growth in the Ghanaian economy. Again, the study found statistically significant and negative effects of inflation on economic growth. This means inflation is inimical to economic growth.
3. Finally, the Granger causality test results revealed a unidirectional relationship between electricity consumption and economic growth running from economic growth to electricity consumption. This implies that economic growth Granger causes electricity consumption whereas the

Bounds tests results from the long-run shows that the direction of causality is from electricity consumption to economic growth.

Policy Recommendations

The study brought to light the importance of electricity consumption, financial development, inflation and capital investment in influencing economic growth in Ghana. Taking cognisance of this, the following recommendations are proposed to help achieve a higher and sustained economic growth in Ghana.

The study found strong evidence to support the fact that electricity consumption acts as engine of economic growth and that economic performance in Ghana can be enhanced through increases in electricity demand. However, the electricity sector in Ghana is operating at low capacity level. To meet increased electricity demand, planning and investment in electricity infrastructure development is essential. In respect of this, government should intensify Public-Private Partnership (PPP) investment in the electricity sector since PPP remains one of the most innovative options that can be deployed to mobilize more resources for energy infrastructure development. Again, the Electricity Company of Ghana (ECG) could also work with other stakeholders in the electricity sector to draft and implement policies so that sustainable electricity supply may be ensured. Also, the Ghanaian economy should not rely mainly on the hydro-electricity generation (thus electricity generated from water sources) because of the cyclical nature and seasonal fluctuations of water availability. The Energy Commission and the Public Utilities Regulatory Commission (PURC) should therefore devote more effort towards developing other sources of energy such as thermal, solar and wind energy for the country.

The study also revealed a positive relationship between financial deepening and economic growth which is an indication that financial deepening plays an important role in growth of the economy. In respect of this, government with the Bank of Ghana and other stakeholders in the financial sector should deepen and maintain a continued implementation of the financial sector reforms in order to foster a growing financial deepening so as to promote economic growth. To ensure development of the financial sector, the Bank of Ghana in conjunction with other financial institutions could revise the conventional financial institutional lending to make it more conducive for micro-borrowing. Solidarity group lending, where a group member can guarantee for one another should also be encouraged to allow the poor access to credit at low cost without requiring collateral. This will facilitate the development of financial services leading to financial deepening.

In addition, government could consider creating and maintaining macroeconomic stability necessary for energy development and competition while encouraging the stakeholders in the electricity sector to enhance technological and human resource development for efficient delivery of electricity services. Overall, the more stable the economy, the better will be the prospect of huge output growth. Therefore, inflation should be kept at a moderate rate since high rate of inflation indicate high level of distortion in Ghana.

Finally, the study also showed a positive relationship between capital stock and GDP growth. This implies that GDP growth could be achieved in Ghana by increasing savings so as to raise adequate capital. Despite the significant role of capital in the growth process of Ghana, there is low capital formation which has resulted in shortage of capital. The problem of shortage of capital is mainly due to low savings. Thus, increasing savings could make adequate capital available to investors. To increase savings in Ghana, one way is for the government through the central bank and other stakeholders in the banking sector to institute deposit insurance schemes to safeguard depositors. This will encourage savers to put more money at the bank. This would help mobilize adequate capital which could be channeled to investors to produce more output to increase the gross domestic product of Ghana.

Also, the Bank of Ghana could also work with other stakeholders in the financial sector to draft and implement policies aimed at ensuring the ready accessibility of credit for investment at moderate cost. In addition, the Bank of Ghana together with the players in the financial market must also design policies to improve the efficiency of savings mobilisation through the banking system accompanied by efficient allocation of resources to the productive sectors of the economy.

Limitations of the Study

This study is not free of drawbacks. The main limitation of the study had to do with the quality and limited availability of annual data on some key variables such as electricity consumption and labour force used in the study. For instance an attempt to extend the data length backwards from 1971 to 1960 or further was constrained by unavailability of data.

Future Direction of Research

The main focus of this study has been to examine the relationship between electricity consumption on economic growth at the aggregate level. It would be more interesting if the impact of electricity consumption on economic growth can be disaggregated in at least three major sectors: (a) the agricultural sector, (b) the industrial sector and (c) the services sector. By doing this, the channels through which electricity consumption may affect economic growth could be highlighted.

Secondly, a comparative study between pre-reform and post-reform scenario pertaining to the electricity sector can be done so as to draw better conclusions. During reforms, different policies are adopted so a study can be done to evaluate the impact of these policies on economic growth.

Finally, since electricity consumption is such an important element for economic growth, further support or research should be devoted towards the exact mechanism by which it influences economic growth.

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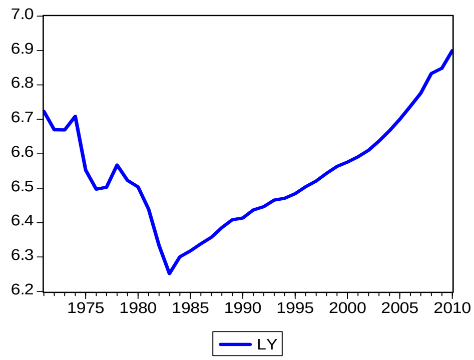
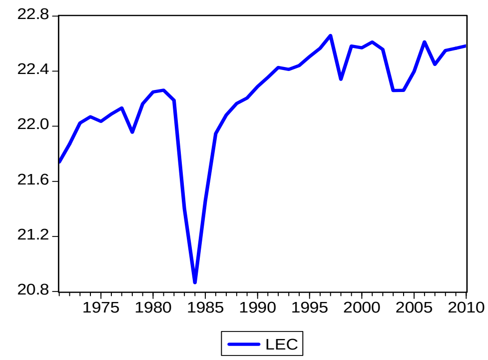
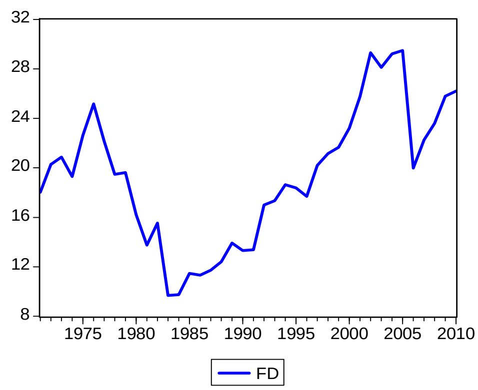
APPENDICES

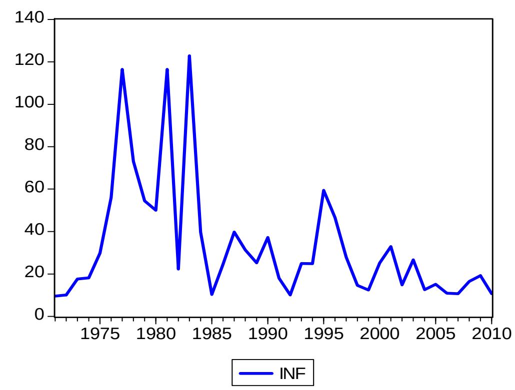
APPENDIX A

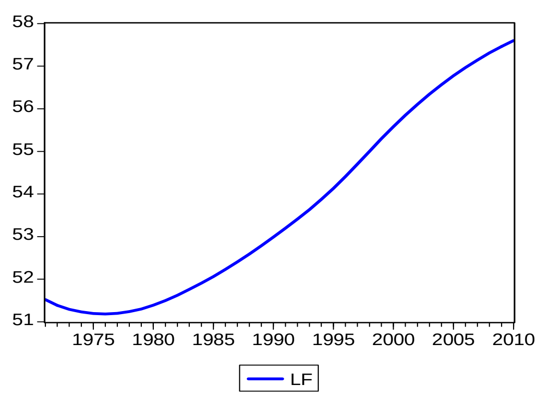
RESULTS OF PLOTS OF VARIABLE IN LEVELS







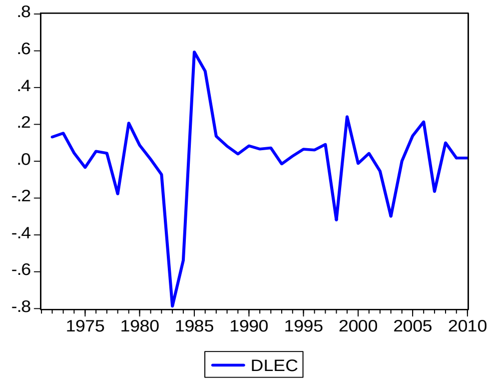


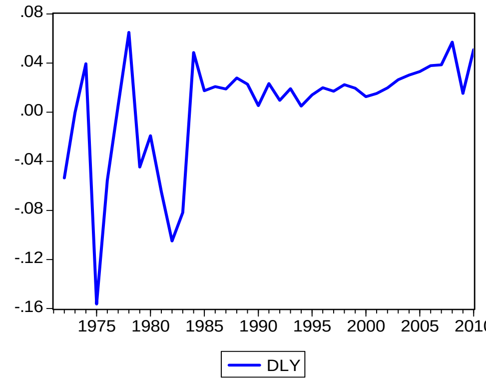


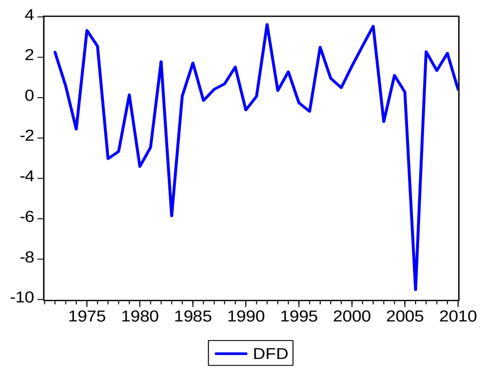
Source: Generated by the author using Eviews 5.0

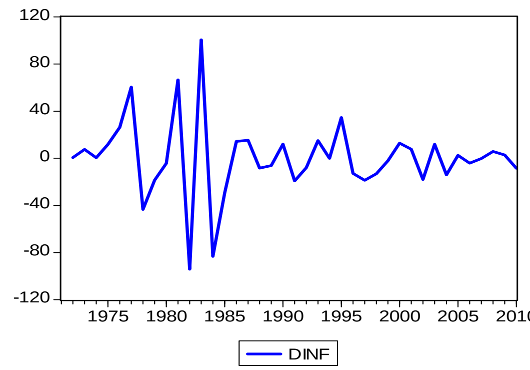
APPENDIX B

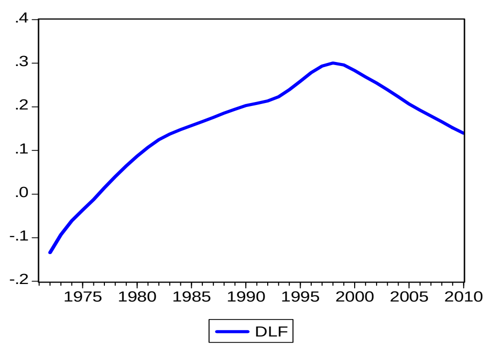
RESULTS OF PLOTS OF VARIABLE IN FIRST DIFFERENCE











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APPENDIX C

TEST FOR THE ORDER OF INTEGRATION (AUGMENTED DICKEY FULLER): LEVEL AND FIRST DIFFERENCE WITH INTERCEPT

Levels (Intercept)			1st Difference (Intercept)			
Var.	ADF-Statistic	Lag	Var.	ADF-Statistic	Lag	*OI*
LY	-0.1367(0.9379)	1	DY	-4.207(0.0021)***	0	*I*(1)
LEC	-2.6463(0.1929)	0	DLEC	-5.42159(0.000)***	1	*I*(1)
LK	-1.17553(0.6754)	0	DLK	-6.50816(0.000)***	0	*I*(1)
FD	-1.1792(0.6737)	0	DFD	-6.31189(0.000)***	0	*I*(1)
INF	-5.29(0.000)***	0	DINF	-7.7464(0.000)***	0	*I*(0)
LF	-2.1023(0.2450)	5	DLF	-6.9535(0.000) ***	1	*I*(1)

Note: D denotes first difference. *** and * represent significance at the 1% and 10% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration.

Source: computed using Eviews 5.0 Package

APPENDIX D

TEST FOR THE ORDER OF INTEGRATION (AUGMENTED DICKEY FULLER): LEVEL AND FIRST DIFFERENCE WITH INTERCEPT AND TREND

Levels (Trend & Intercept)			1st Difference (Trend & Intercept)			
Var.	ADF-Statistic	Lag	Var.	ADF-Statistic	Lag	*OI*
LY	-1.228207 (0.8901)	1	LY	-5.275(0.0006) ***	0	*I*(1)
LEC	-2.67079(0.1369)	1	DLEC	-5.339(0.0005) ***	1	*I*(1)
LK	-2.579303(0.2913)	0	DLK	-6.413(0.0000) ***	0	*I*(1)
FD	-1.631907(0.7617)	0	DFD	-6.346(0.0000) ***	0	*I*(1)
INF	-5.6811(0.0013) ***	0	DINF	-7.787(0.0000) ***	1	*I*(0)
LF	-2.117969 (0.5183)	4	DLF	-5.042(0.0000) ***	3	*I*(1)

Note: D denotes first difference. ***, ** and * represent significance at the 1%, 5% and 10% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration.

Source: computed using Eviews 5.0 Package

APPENDIX E

TEST FOR THE ORDER OF INTEGRATION (PHILLIPS PERRON): LEVEL AND FIRST DIFFERENCE WITH INTERCEPT

Levels (Intercept)			1st Difference (Intercept)			
Var.	PP-Statistic	Bwd	Var.	PP-Statistic	Bwd	*OI*
LY	-0.33065(0.9110)	3	DLY	-4.16(0.0023)***	3	*I*(1)
LEC	-2.167788(0.2208)	3	DLEC	-4.74(0.0005)***	3	*I*(1)
LK	-1.09707(0.7074)	2	DLK	-6.61(0.0000)***	4	*I*(1)
FD	-1.61679(0.6388)	3	DFD	-6.31(0.0000)***	3	*I*(1)
INF	-5.40(0.0001)***	4	DINF	-14.66(0.000)***	6	*I*(0)
LF	1.92350(0.9997)	5	DLF	-3.39(0.0074)***	5	*I*(1)

Note: D denotes first difference. ***, ** and * represent significance at the 1%, 5% and 10% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration. Bwd represents bandwidth.

Source: computed using Eviews 5.0 Package

APPENDIX F

TEST FOR THE ORDER OF INTEGRATION (PHILLIPS PERRON): LEVEL AND FIRST DIFFERENCE WITH INTERCEPT AND TREND

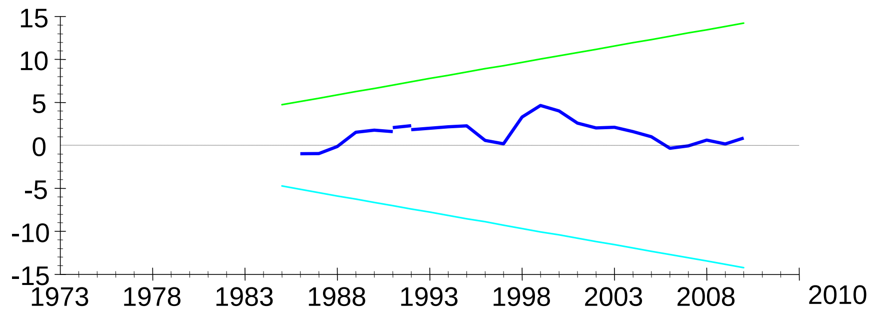
Levels (Trend & Intercept)			1st Difference (Trend & Intercept)			
Var.	PP-Statistic	Bwd	Var.	PP-Statistic	Bwd	*OI*
LY	-1.258618(0.8834)	3	DLY	-5.21 (0.0007)***	3	*I*(1)
LEC	-2.732248(0.2300)	3	DLEC	-4.66 (0.0032)***	3	*I*(1)
LK	-2.618067(0.2749)	1	DLK	-6.50(0.0000) ***	4	*I*(1)
FD	-1.686961(0.7381)	3	DFD	-6.36 (0.0000)***	2	*I*(1)
INF	-5.68(0.0002) ***	1	DINF	-15.6(0.0000)***	8	*I*(0)
LF	-2.117969(0.5183)	4	DLF	-5.04(0.0000) ***	3	*I*(1)

Note: D denotes first difference. ***, ** and * represent significance at the 1%, 5% and 10% levels respectively. Numbers in brackets are P-Values. *OI* represents the order of integration. Bwd represents bandwidth.

Source: computed using Eviews 5.0 Package

APPENDIX G

PLOT OF CUMULATIVE SUM OF RECURSIVE RESIDUALS

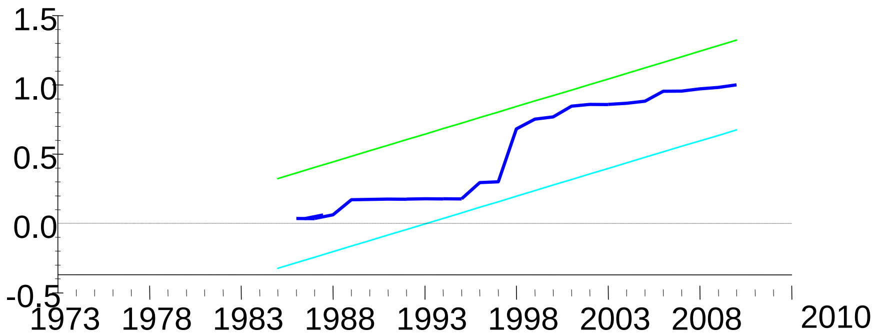


The straight lines represent critical bounds at 5% significance level

Source: Generated by the author using Microfit 4.1

APPENDIX H

PLOT OF CUMULATIVE SUM OF SQUARES OF RECURSIVE RESIDUALS



The straight lines represent critical bounds at 5% significance level

Source: Author's computation using Microfit Version 4.1

APPENDIX I

DATA USED FOR THE STUDY

year	LF	INF	FD	M	D	LK	LEC	LY
1971	51.521	9.5588	18.032	1	0	2.5207	5.7371	22.726
1972	51.387	10.067	20.287	0	0	2.1595	5.8398	22.701
1973	51.293	17.683	20.867	0	0	2.0353	5.9629	22.729
1974	51.232	18.135	19.297	0	0	2.4774	5.9811	22.796
1975	51.196	29.825	22.631	0	0	2.4526	5.9240	22.663
1976	51.183	56.081	25.176	0	0	2.2859	5.9587	22.627
1977	51.197	116.45	22.151	0	0	2.2405	5.9853	22.650
1978	51.238	73.092	19.486	0	0	1.6215	5.7923	22.731
1979	51.302	54.441	19.621	0	0	1.9064	5.9800	22.705
1980	51.389	50.070	16.210	1	0	1.8079	6.0432	22.710
1981	51.497	116.50	13.756	1	0	1.5524	6.0250	22.674
1982	51.621	22.296	15.541	0	0	1.2617	5.9195	22.603
1983	51.759	122.88	9.6841	0	1	1.3247	5.0976	22.556
1984	51.906	39.665	9.7515	0	1	1.9247	4.5257	22.639
1985	52.063	10.305	11.468	0	1	2.2544	5.0865	22.687
1986	52.229	24.565	11.325	0	1	2.2295	5.5461	22.739
1987	52.405	39.815	11.735	0	1	2.3380	5.6535	22.786
1988	52.591	31.359	12.414	0	1	2.4194	5.7092	22.841
1989	52.785	25.224	13.927	0	1	2.5769	5.7217	22.891
1990	52.988	37.259	13.312	0	1	2.6663	5.7780	22.923
1991	53.196	18.031	13.376	0	1	2.7615	5.8166	22.975
1992	53.409	10.056	17.002	1	1	2.5444	5.8604	23.013
1993	53.633	24.960	17.347	1	1	3.1691	5.8174	23.060
1994	53.872	24.870	18.635	1	1	3.1168	5.8179	23.093
1995	54.130	59.462	18.380	1	1	3.0507	5.8576	23.133
1996	54.409	46.561	17.696	1	1	3.0106	5.8930	23.178
1997	54.702	27.885	20.194	1	1	3.1712	5.9609	23.219

Data used in the study continued

1998	55.002	14.624	21.156	1	1	3.1074	5.6185	23.265
1999	55.298	12.409	21.652	1	1	3.0189	5.8366	23.308
2000	55.581	25.193	23.214	1	1	3.1398	5.8003	23.344
2001	55.845	32.905	25.767	1	1	3.3004	5.8187	23.384
2002	56.104	14.816	29.305	1	1	2.9325	5.7408	23.428
2003	56.343	26.675	28.119	1	1	3.1328	5.4177	23.478
2004	56.566	12.625	29.216	1	1	3.3456	5.3946	23.533
2005	56.773	15.118	29.494	1	1	3.3674	5.5079	23.590
2006	56.965	10.915	19.981	1	1	3.0744	5.6979	23.652
2007	57.144	10.733	22.255	1	1	3.0011	5.5101	23.715
2008	57.310	16.522	23.596	1	1	3.0658	5.5864	23.796
2009	57.461	19.251	25.795	1	1	2.9741	5.5801	23.835
2010	57.601	10.708	26.2041	1	1	3.10928	10.1915	23.9091

Source: world Bank, (2011).