UNIVERSITY OF CAPE COAST

ELECTRICITY GENERATION AND ECONOMIC GROWTH IN GHANA

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BY

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DECLARATION

Candidate's Declaration

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

Candidate's Signature:.. Date:..........................

Name: ABDUL-RAZAK SAWAL ALHASSAN

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 sectorial relevance and direction of energy policy in the Ghanaian economy as energy demand continue to rise with constant growth in services and a steady decrease in manufacturing growth, requires empirical analysis of the relationship between electricity generation and economic growth. This study analyses time series data from 1983 to 2015 to examine long run cointegration between electricity generation and economic growth using Autoregressive Distributed Lag Model (ARDL) bounds testing of cointegration and Granger causality. We find that in the long run electricity generation affects economic growth. We establish a feedback effect between electricity generations to economic growth. The policy implication is that as more investments are made in the electricity sector, it will boost economic growth which will lead to more investments in the energy sector for further growth.

KEY WORDS

Autoregressive Distributed Lag (ARDL) Model

Cointegration

Economic Growth

Granger Causality

Investments

Manufacturing

Services

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DEDICATION

To my beautiful daughter, Princes Abdul-Razak Neenah and my awesome wife Abdul-Razak Siham.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AIDS	Acquired Immune Deficiency Syndrome
ARDL	Autoregressive Distributed Lag
BT	Bounds Test
CRRA	Constant Relative Risk Aversion
CUSUM	Cumulative Sum of Recursive Residuals
CUSUMSQ	Cumulative Sum of Squares of Recursive Residuals
ECM	Error Correction Model
ECT	Error Correction Term
GDP	Gross Domestic Product; measure of wealth of an economy of a nation.
LPG	Liquefied Petroleum Gas
Solar PV	Solar Photovoltaic; panel technology for electricity via solar or sunshine
GW	Gigawatt, i.e. million units of electricity
kW	Kilowatt, i.e. one unit of electricity
MW	Megawatt, i.e. thousand unit of electricity
NG	Natural Gas
ECG	Electricity Company of Ghana, a public power distributor
VRA	Volta River Authority, a public power generator
VALCO	Volta Aluminium Company, a smelting company

WAGP	West African Gas Pipeline
GLS	Generalised Least Squares
HQC	Hannan Quinn Criterion
IFS	International Financial Statistics
IMF	International Monetary Fund
LDCs	Less Develop Countries
LR	Long-Run
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PP	Phillip-Perron
RESET	Regression Specification Error Test
SBC	Schwarz Bayesian Criterion
SDGs	Sustainable Development Goals
SIC	Swartz Information Criterion
SR	Short-Run
SSA	Sub-Saharan Africa
UK	United Kingdom
US	United State
VAR	Vector Autoregressive
WDI	World Development Indicators
WEIM	World Energy Indicators Monitor
UNIDO	United Nations Industrial Development Organisation
GFZB	Ghana Free Zone Board
ISSER	Institute of Statistical Social and Economic Research

UNDP	United Nations Development Program
WHO	World Health Organization
WEO	World Energy Outlook
GoG	Government of Ghana
ECPD	Electricity Coincidence Peek Demand
WSPRAR	Whole Sale Power Reliability Assessment Report
WEC	World Energy Council
ERP	Energy Situation Reports

CHAPTER ONE

INTRODUCTION

Background to the Study

Power outages are demonstrated to reduce output below the production frontier by 5 percent in Africa and by a lower percentage in South Asia, Southeast Asia and the Middle East and North Africa (Bee, 2016). Production response to outages is in quadratic form (World Energy Council, 2016). Outages also increase labour cost, reduce exports of manufacturing product and slightly increase imports of intermediate materials (Birol, 2010). The rate of inefficiency in manufacturing, however, is not higher in countries with state ownership of the transmission and distribution grids (Bee, 2016).

The effect of externalities are a plausible explanation for the neglect of the unmeasured importance of electricity for economic growth, particularly in LDCs where the assumption of unconstrained availability of electricity and intermediate inputs are often neglected. Electricity cannot be stored and that presents another reasonable explanation of the less importance of electricity to growth. When electricity is part of an industry's technology, labour and capital produces zero marginal product during electricity outages. Also substitution with other forms of energy are not possible in the short-term because of the unpredictable nature of electricity outages. A third ideal explanation for the unmeasured relevance of electricity in economic growth is substitution of imported intermediates for locally produced intermediates.

Wolde-Rufael (2009), draws these conclusions about electricity's role in productivity from economic history: first, abundant availability of energy on favourable terms encouraged the spread and development of new technologies which favoured the use of energy relative to labour and to a lesser extent energy relative to capital. These raised the combined productivity of capital and labour. Second, increased use of electricity and fluid fuels explain much of the productivity improvements in manufacturing. Technical change that exploited the quality characteristics of these fuels explains the simultaneous improvements in TFP, labour productivity, and energy productivity. Innovations in technology triggered by the adoption of new energy sources lowered total production costs. The improvement in productivity was not merely because of falling energy costs during the period (Yoo and Kim, 2006). Lastly, electricity did much more than replace human and animal muscles. It was a management tool for reorganization of production systems which provided precise control, highly focused application, fractional use and linkages to technological systems (World Energy Council, 2017).

Industrializing Africa and the LDC economies were identified as one of four reasons why growth policies must be revised (Snow, 2017). It is unlikely that Africa and LDCs can meet the Sustainable Development Goals by 2030, particularly SDG 9 on industry, innovation and infrastructure if it fails to industrialized their economies. The Uncertainties of these lagging economies, Africa and the LDCs, is heightened by the emerging concerns surrounding "peak demand" and "stranded resources", as major electricity supply constraints (World Energy Council, 2017).

Half of the world's capital investments have been made in innovative energy technologies and related infrastructure (Lima, Nunes & Cunha, 2016).

This trend stand the potential of being obsolete as cyber threats are already keeping leaders in Europe, East Asia and North America alert (WEC, 2017). In Africa and LDCs, inclusive and sustainable industrial development is associated with job creation, sustainable livelihoods, innovation, technology and skills development, food security and equitable growth still being the key requirements for eliminating poverty by 2030 (IEA, 2016).

There is consistent decline in access to electricity in Africa as compared to the rest of the regions in the world despite the region's huge potential for renewable energy, including hydropower, solar, and geothermal (IEA, 2014). One of the basic objective for the presence of World Bank in Africa is to stimulate access to affordable, reliable and sustainable energy (Lima, Nunes & Cunha, 2016).

Martinho (2011) noted that from the beginning of industrial revolution in the early nineteenth century, manufacturing sectors have stimulated expansion for all economies through spill-over effects to other sensitive sectors. The advanced countries had achieved great prosperity, profitability, and remarkable growth in their respective economies as they harnessed their power potentials (Odhianho, 2010). Experiences in developed nations and the emerging economies of China, India, North Korea, Malaysia, and Singapore resulted a positive correlation between manufacturing sector growth and national economic growth (Haraguchi, Cheng & Smeets, 2017). The developing economies with agrarian and services oriented in the past also evolved several initiatives to sustain the development of their manufacturing sectors (Ghani, 2011).

In 2017, the Bank provided $700 million in investments for the Sankofa Gas Project in Ghana. Gas from the project is projected to generate about 1,000 megawatts of power. The project will leverage $7.9 billion in private sector investments, yielding huge potential of fiscal returns and benefits to Ghana (Snow, 2017). The project will make for about 40 percent of Ghana's currently installed generation capacity.

With a declining manufacturing sector, Ghana lost between $320million and $920 million annually in productivity and economic growth due to unstable power supply the country experienced (Institute of Statistical, Social and Economic Research 2015). It is interesting to look at the supply of the electricity and examine the relationship between manufacturing growth, electricity generation and economic growth. Gabriele (2014), argued that services sectors such as software, business processing, finance or tourism may act as leading sectors in development and that the role of manufacturing is declining. These seems to be taking shape in most developing countries including Ghana. Soderbom and Teal (2003), found evidence of a positive relationship between growth of income and growth of exports in selected African countries. (Soderbom and Teal, 2012), agreed with the wider findings that there is positive impact of trade on growth, they however recognised that poor macroeconomic policy, overvalued exchange rates and constraints on imports can gloom the prospects of the export sector. An obvious hindrance to most economies in Africa to expand, is because of poor macro policies and a high cost of business environment (Steven & Leen, 2006). Haraguchi, Cheng and Smeets (2017), insisted that these factors specifically stifles manufacturing exports. The stale of Ghana's economic growth up from 7.4% in 2013 down to 4.2% in 2014 was attributed to low performance of the manufacturing sector, low oil production from offshore Jubilee field, gas supply interruptions from Nigeria, persistent break in power supply, rising inflation and fall in value of the cedi as key determinants of the slow growth (ISSER, 2015). Eshun and Amoako-Tufuor (2016), posit that source of energy for industrial production in Ghana is an absolute derivative of electrical energy.

We seek to examine the relationships between electricity generation and economic growth. Our work seeks to explain the relationship between these all-important variables as the country poised to embark on expansion of the manufacturing sector of our economy.

Also, labour productivity, a measure of output per employee was high in South Africa and low in Ghana (Kutin-Mensah, Huang, Boateng & Chinpong, 2017). These variations in labour productivity were reflected in capital intensity policies, showing evidence of lowest level of capital per employee in Ghana (Newman, Page, Rand, Shimeles, Soderbom & Tang, 2016).

Generation of electricity in Ghana has gone through several stages, right from diesel generators and stand-alone electricity supply systems established by industrial mines and factories, to the hydro phase following the construction of the Akosombo dam, and now thermal systems powered by gas and/or light crude oil (Eshun and Amoako-Tuffuor, 2016). Eshun and Amoako-Tuffuor (2016), argued that access and adequate supply of electricity will lead to sound economic growth. We drive it inspirations from the argument that supply side of electricity has a very huge impact on industrial production and revenue generation and basically determines value addition in every economy. We agree with the assertion that modern sources of energy pertains to electricity, liquid fuels, and gaseous fuels, natural gas, and do not include traditional biomass and coal (UNCTAD, 2015). Deficient access to these sources of energy impressively affects health, stifles opportunities and widens the gap between the rich and the poor (Adom, Bekoe, &Akoena, 2012). There is a wide variation among developing countries with respect to access to modern fuels but more limited in the Least Developed Countries and sub-Saharan Africa (WEC, 2017).

Electricity generation underpins a wide range of products and services that improve quality of life, increases productivity and encourages entrepreneurial activity (Adom et al., 2012). Overall, more than 40 percent of people in developing countries rely on modern fuels, however, only 9 percent and 17 percent have access to modern fuels in LDCs and sub-Saharan Africa respectively (Snow, 2017). This low in access has the potential of staling economic activities at the micro level which sum effect abound low economic growth (Adom et al., 2012). Major source of electricity generation in Ghana is by hydro from the Akosombo dam, Bui dam and Kpong Hydro Plant (Energy Commission, 2015). It is relevant to determine the economic relationship between quantity of electricity generation and economic growth. Increasing generation capacity, widening of the distribution networks, consistency of power supply, reduction of technical and commercial losses, and access to natural gas feedstock are areas of focus in the power and energy sectors for the Government of Ghana to maintain economic growth (Energy Commission, 2015).

The demand for electricity is increasing while there is enormous supply gap, which increases at a faster pace (CEPA, 2007). A projected Electricity Coincident Peak Demand (ECPD) for the year 2014 was 2,179.5MW. This represented an increase of 236.6MW, an additional demand of 12.2%, over the 2013 peak demands (Energy Commission, 2015). The increase occurred because of mines, industrial customers, residential and new loads emanating from rural projects (WEC, 2017).

Electricity fluctuations has become a common development challenge in Ghana, with increasing severity that threatens the country's economic growth and transformation. The troubling rationing system the country was subjected to, slowed industrial activity, increased job and income losses, and created disruptions in social life now seem a perennial haul on Ghana's economic development (UNIDO, 2015).

The link between economic growth and energy remains inconclusive in literature. This work seeks to establish the relationship between electricity generation and economic growth in Ghana. This study seeks to establish the relationship between electricity generation and economic growth in Ghana. The Wholesale Power Reliability Assessment report (2010) also estimated that Ghana loses between 2% and 6% of gross domestic product (GDP) annually due to inadequate and unreliable power supply. Thus, with the economic costs of inadequate power supply, a reliable and adequate supply of power becomes even more pressing. While Ghana has committed itself to universal electricity access by 2020, the real challenge is the capacity to meet this goal and, most importantly, to ensure that supply is reliable and adequate (UINDO, 2016).

Respective governments have also failed in their quest towards building a sustainable and resilient power supply systems to cater for the incessant demand for power. Especially for a lower middle income country like Ghana, it is important to recognize the growth of industries and the increasing population growth in relation to the increase in power demand (Kwakwa, 2012).

This study intends to focus on electricity generation and economic growth in Ghana. The motivation of the study is based on the country's vision on industrialization and Sustainable Development Goal 9 on industry, innovation and infrastructure. In that sense, this studies is relevant to development planning of the country.

Statement of the Problem

Quantitative journey to resolve economic relationship between energy and economic growth is enormous and in most cases skewed to energy consumption and economic growth. In the past two decades, examination of the relationship between economic growth and electricity generation has been minimal. This study outlines the trends and state of Ghana's current power demand and supply gaps and the major impediments to resolving the supply bottlenecks; highlights power supply capacity constraints, manufacturing share of GDP, and development implications on export-led economy as the country envision to enroot. We seek to identify key issues that should be the focus of policy decision-making going forward. This study begins with some elaboration on the current electricity situation by highlighting the demand drivers and the supply-demand mismatch, the challenges, the energy sector initiatives implemented over the years, and the growth and development implications. Finally, the study discusses the demand- and supply-side options available with alternatives in the energy mix and a focus on private sector participation.

Greater number of findings confirms that there exists a strong relationship between electricity consumption and economic growth. But literature basically elaborate on demand for electricity relative to income and energy prices and economic growth (Tang, Shahbaz & Shahbir, 2011). In most cases unresolved or conflicting conclusions are made with similar statistical tools and economic theories. Gosh (2009), constructed a model that constituted employment, electricity generation and GDP and concluded that there was a unidirectional short term causality from economic growth to electricity supply. Lean and Smyth (2010), found that increase in economic growth led to increase in electricity generation in Malaysia. There are probably two possibilities why these occurred. First, economic growth resulted in the expansion of services, commercial and industrial sectors and manufacturing which all run on electricity as basic input. Secondly, manufacturing sector is touted as the key driver to economic growth in Malaysia and consumes almost one-half of electricity generated (Lean & Smyth, 2010).

Several of these studies has been done in Ghana (Kwakwa 2012, Adom et al 2012, Eshun & Amoako 2016) to ascertain the relationship between electricity consumption and economic growth. These findings affirm stronger relationship between the two variables as elaborated in literature. The relation between energy consumption and economic growth was first examined by (Kraft and Kraft, 1978). Several studies have made several attempts since, to explain the economic relationship between energy consumption and economic growth with conclusion that bars consensus on results (Ozturk, 2011). This inconclusiveness led to four types of hypothesis. These includes the neutrality, conservation, growth and feedback hypothesis. Some major studies that studied these hypotheses includes (Altinay & Karagol, 2005), (Narayan & Singh, 2007), (Apergis & Payne, 2009) and (Rashid & Abdur Alam, 2010).

The study of electricity generation and economic growth is an emerging trend in literature. Yoo and Kim (2006), found causal relationship from economic growth to electricity generation. The study of electricity supply, employment and GDP using multivariate, to avoid specification bias due to omission of relevant variables, led to a unidirectional short term causality from economic growth to electricity supply (Ghosh, 2009). Yoo and Kim (2006), argued that evidence on either causality shall have a significant bearing upon policy. If, for example, there is unidirectional causality running from electricity generation to economic growth, reducing electricity generation could lead to a fall in economic growth (Sarker, 2010). On the other hand, if a unidirectional causality runs from economic growth to electricity generation, it could imply that policies for reducing electricity generation may be implemented with little or no adverse effects on economic growth (Sambo, Gariba, Zarma & Gaji, 2012). Lastly, no causality in either direction would indicate that policies for increasing electricity generation do not affect economic growth (Lean & Smyth, 2010). Sarker (2010) have explained that the variation in empirical findings could be due to different economic structure of countries being studied and the fact that different economies have different consumption pattern and various sources of energy.

An extension of Yoo and Kim’s (2006) study by (Sarker & Rashid 2010), by studying electricity generation and economic growth yielded strong economic relationships. Bayraktutan et al, (2011) examined the relationship between electricity generation from renewable sources and economic growth on OECD countries and found a long term positive relationship between renewable electricity generation and economic growth with bidirectional causality between these variables but Lean and Smith, (2010) has been the first in literature to widen the scope of these dynamics to include electricity generation, economic growth, exports and prices in a multivariate model for Malaysia.

We will further deepen literature by looking at the specific case of electricity generation and economic growth. Not much study has been done to appreciate how supply of electricity affects economic growth. Our study specifically want to measure the relationship between electricity supply and economic growth. Electricity shortage and other external factors have combined to slow the pace of development in recent years, leading to a depreciating currency and a budget deficits reflecting fall in industry performance and international export competitiveness in Ghana (BMI, 2016). It is important to understand the dynamics between electricity production and economic growth to offer effective policy prescription on how to improve industry performance and a healthy competition in international export. There have been several studies on electricity consumption and economic growth in Ghana by Kwakwa (2012), Adom (2011), Eshun and Amoako (2016), but no study has addressed why with increased in generation capacity, the country's manufacturing sector still suffers a steady decline in growth. This study seeks to resolve the dynamics that underpins the economic relationships of the electricity production and growth in Ghana.

To what extend does electricity generation affects economic growth in the long run in Ghana? Is it possible for an increase investment in electricity brings about an increase in economic growth and the vice versa? Which of the conflicting hypothesis in literature is true for Ghana? This and many questions shall be resolved in this work.

Objectives of the Study

The general objective of the study is to investigate relationship between electricity generation and economic growth in Ghana from 1983 to 2015.

Specifically, the study seeks to;

- Examine long run relationships between electricity generation and economic growth
- Establish direction of causation between electricity generation and economic growth

Hypotheses of the Study

1. H_0: There is no long run economic relationship between electricity generation and economic growth

   H_1: There exist long run economic relationship between electricity generation and economic growth

2. H_0: There is no causal relationship between electricity generation and economic growth

   H_1: There is causal relationship between electricity generation and economic growth.

Motivation of the Study

We seek to give policy elaborations on how national planning on economic growth in Ghana, with full disclosure on electricity generation as a major stimulant. Our findings will offer empirical advice on the policy alternative that maximises output.

This study will be a major contribution on the single-country study of electricity and growth literature in Ghana. Eventually, the results will widen scholarly perspective on sectorial relevance and direction of energy policy in the Ghanaian economy demand for energy continue to rise with a constant growth in services and a steady decrease in manufacturing growth. We seek to also enrich theoretical understanding of electricity generation and economic growth.

The National Planning Commission, Ministry of Energy, Ministry of Trade and The National Energy Commission as well as Electricity Company of Ghana, will find this study an exciting insight for policy guidelines in planning. We shall examine the relationships between electricity generation and economic growth and the quantitative effects these variable bears on each other within the greater context of the country's economic space. The appreciation of economic relationships between the country's electricity generation capacity, manufacturing value addition and the resultant competitive export sector and its influence on economic development, is rather too important for policy direction. Economic policy formulation needs a complete assessment of how sustainable electricity generation can influence growth that will eventually boost exports to rake in the needed foreign exchange to leverage balance of payment deficit (Yoo and Kim, 2006).

Organization of the Study

The study is organized into five chapters to build method and easy understanding of the underlying concepts and theories. The introductory chapter conceptualizes the back ground of electricity generation and economic growth, statement of the problem, objectives of the study, hypotheses and motivation of the study. Chapter two elaborates on extensive review of both theoretical and empirical literature the related variables while chapter three elaborates on data sources as well as methodological framework and techniques used in the study. We present discussions of results and findings under chapter four build on literature. The study is closed with summary of the study, conclusions drawn from empirical findings, recommendations, limitations and direction of future study in Chapter five.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

This section of the work examines the overview of electricity generation and economic growth taking into consideration services and manufacturing outputs dynamics in Ghana in a top to down fashion. We start by giving brief overview of electricity generation and its challenges across the world and zoom down to Africa and West Africa and eventually Ghana. We present an empirical analysis that underpins current energy situation in literature with close look at model specifications, data and the various related limitations therein.

We also discuss literature on manufacturing and services variables. There is an urgent need to understand how these variables play out in the universal conception of growth with recourse to the contributions of these sectors to Ghanaian economy.

Theoretical Review

Electricity has not been recognized as a significant production factor in neoclassical growth models due to its small share of input into production (Bee, 2016). World Bank Investment Climate Surveys of businesses in LDCs have consistently identified electric supply as the most common constraint on economic output (World Bank, 2016). Externalities are a plausible explanation for the unmeasured importance of electricity for economic growth, especially in low income countries where the assumption of unconstrained availability of electricity and intermediate inputs are often violated. One of three main externalities is, electricity cannot be stored (Chen, 2007). Labour and capital produce zero marginal product during outages of electricity. Secondly, eventually technologies that embody electricity are not adaptable in the short-term to alternate forms of process energy. A third plausible explanation for the unmeasured importance of electricity in economic growth is substitution of imported intermediates for domestically produce intermediates (Chen, 2007).

Industrial production has been central of development theory since the introduction of Lewis's (1954) dual-sector theory and Prebisch's import substitution of industrialization (Todaro and Smith, 2011). Industrialization increases an underdeveloped country's per capita income. Solow (1956) provides the first explanation of how the combination of factor inputs increases per capita income. The Solow model postulates that growth occurs through increased inputs of labour and capital in combination with technological progress. Critiques of Solow's model argued that economic history has demonstrated that additional inputs, such as electricity and fuels, contributed directly to production and therefore should also be included in growth models (Wolde-Rufael, 2009).

Ecological economics postulates that energy is the ultimate factor input and exhibits diminishing returns to transformation and substitution because energy is subject to the laws of thermodynamics (Ayres & Kneese, 1969). Solow growth models provide misleading inferences about factor inputs and future economic growth (Yoo & Kim, 2006).

Several empirical literature examined how variables in electricity generation, transmission and distribution constrain economic growth and on which variables explain variances in electricity and economic output in Ghana. The central research questions in our work borders on the relationship between electricity generation and economic growth. Virtually all studies of electricity demand find inelastic price and income relationships in the short-run and unitary to elastic relationships in the long-run.

The Role of Electricity in Economic History

Solow attributes economic growth to two factor inputs and Total Factor Productivity (TFP). Factor inputs of labour and capital explain less than half of growth in most countries (Ayres & Warr, 2010). A persistent criticism of the Solow model is that TFP is nothing more than a varied category that captures the unexplained variance in growth (Ayres and Warr 2010). The change in the output/capital ratio does not fully capture productivity changes from electrification; however, since changes in power technologies can also affect productivity of labour and material inputs, DuBoff (1966) concludes that the evidence supports the view that electric technology simultaneously increased the productivity of capital, labour, and materials as well as TFP.

Since electricity inputs also affect the productivity of labour, capital, and intermediate materials in manufacturing, the effects are difficult to measure in production function models of the economy. Empirical evidence suggests that the Solow approach fails to capture fully the determinants of productivity growth.

The Critique of Solow by Ecological Economics

The Neo-Malthusians argue that economic growth models ignore the prevalence of negative externalities, such as pollution, in production (Ayres and Kneese 1969). The disposal of these wastes inevitably creates negative externalities that are not captured by resource markets. Stiglitz (1974) notes that three economic forces offset the limitations of natural resources: technical change; substitution of man-made factors of production (capital) for natural resources; and returns to scale. Stiglitz (1974), built a Solow growth model with inputs of exhaustible resources and demonstrates that economies with exhaustible resources can experience constant rates of growth of per capita income, but at lower rates than growth models with only labour and capital inputs. Stiglitz (1974) uses neoclassical production theory to study the issues of energy and economic efficiency. Berndt demonstrates that the minimum energy point is an asymptote to the isocost curve where the relative price of energy is infinite. Stern's explanation of why his findings diverge from neoclassical production theory is because of measurement error.

The most important measurement issues in neoclassic production theory, however, are the assumption of uniform quality of energy inputs. All forms of energy should not be considered of equal quality in production functions. Stern (2003) summarizes why ecological economics and neoclassical economics differ in terms of energy's role in productivity. Ecological economics sees energy as a non-renewable factor of production whose use is governed by the first and second laws of thermodynamics.

Other factors of production cannot therefore be perfect substitutes for energy. Since all industrial production involves transformation or movement of matter, production requires energy. In sum, energy is the only primary factor of production and all value added accrues to energy.

The criticisms of neoclassical growth theory by ecological economics focus on the limits to substitution of energy for other inputs and the limits of technological progress in mitigating the scarcity of resources (Bee, 2016). The thermodynamic limits on transformation result in diminishing marginal returns on transformation. The dispute in the literature between neoclassical production theory and ecological economics on the role of energy in production remains unresolved. The axiom of diminishing returns to transformation in ecological economics assumes that resources are fixed and finite. The recent discovery of shale technology and the rapid growth in U.S. oil production suggests that the availability and price of natural resources as factor inputs respond to technological progress, as argued in neoclassical production theory (Verleger, 2015). Technical progress and substitution of other factors of production can offset the effects of dwindling resource stocks on economic growth.

Energy and Electricity as Paid Factors of Production

While ecological economics uses causality tests and new variables to measure the connection between electricity and industrial production, neoclassical economists attempt to measure its effects by including electricity as a paid input in production function models of the economy. If electricity is an important input into production, it will serve as a substitute or complement to other factors of production that can be measured in production function models.

Berndt (1978) observes that econometric studies on aggregate energy demand have consistently reported substantial energy-labour substitutability. This means increases in relative energy prices will lower labour productivity, making energy a link between per capita income and labour productivity.

The investigation of energy as a paid factor input confirms that it exhibits substitution and complementary effects with other factor inputs but that its effects are difficult to measure because it is closely tied to investment and write-offs of capital equipment. In addition, the evidence suggests that energy plays an additional role in augmenting TFP. Energy, therefore, has properties of an unpaid and paid factor of production.

Electricity as an Unpaid Factor of Production

Much of the theoretical literature on energy and productivity investigates the presence of externalities that are not captured in neoclassical growth models due to measurement error or because electricity is an unpaid factor of production where the price is not set by market forces. The effects of electricity are captured largely in TFP rather than as a production input. Electricity has played important roles in improving industrial productivity because of its quality features. Electricity offers more precise control of heat and mechanical energy. Direct substitutes for electricity do not exist in many industries. Production function models that assume all energy forms are perfect substitutes are unable to accurately measure the role of electricity in productivity.

Electricity is generally recognized as one of the oldest General Purpose Technologies. Because of pervasive externalities, GPT's are difficult to measure in production functions. The changes due to technological complementarity stem from new products, new factors of production, and new production functions. Apergis and Payne (2010) argue that the treatment of infrastructure as a factor input in previous studies violates marginal productivity theory since its unit cost is not market determined. It is invalid to assume that infrastructure is remunerated based on its marginal product. The marginal product of labour is a cubic function represented as:

$$MP_L = Q\left(\frac{\beta_1}{L} - \frac{\beta_2}{L^2} + 2\beta_2\beta_3\frac{K}{L^3}\right) \qquad (1)$$

Where MPL is the marginal product of labour and production. Labour initially increases the marginal product of labour then decreases it. The marginal product eventually turns negative when excess labour is used with capital.

Canning and Bennathan (2000) estimate the social rates of return to electricity- generation and paved-road infrastructure using an aggregate production function for a panel of countries from 1959 to 1999. Canning and Bennathan find that infrastructure, including electric generation capacity, is strongly complementary with both physical and human capital. For electricity generation, Canning and Bennathan (2000) find a turning point between the elasticity of electric infrastructure investment and per capita income.

Canning and Bennathan also estimate the relative cost of infrastructure using social rates of return. On average, the returns to investments in generating capacity exceed the returns to physical and human capital in poor countries. The social returns to these forms of capital exceed the private returns estimated in World Bank cost-benefit studies. Microeconomic tools, like cost/benefit analysis, miss benefits of infrastructure due to externalities.

Hulten, Bennathan, and Srinivasan (2006) examine the spill over externalities of infrastructure in manufacturing industries in India between 1972 and 1992 using an aggregate production function with observations consisting of Indian states. HB&S place infrastructure directly in the production function for manufacturing output as an unpaid factor of production. The production function model is:

$$Q = A(B,t)F(K,L,M(B)) \qquad (2)$$

Where Q is output, B information stock, t is a time trend, K is privately-owned capital, L is labour, and M are intermediate inputs.

The above formula captures infrastructure into the manufacturing industry through "market-mediated effects" and "non-market mediated infrastructure" channels. Changes in infrastructure stock also raise output from efficiency-promoting externalities which are captured in TFP. The explanation is that increased electric-generating capacity promotes continuous supply and allows the use of more sophisticated machinery and reduces the need for self-generation of electricity. The total effects of electricity infrastructure consist of the direct and indirect effects.

Beenstock, Goldin, and Haitovsky (1997), derive the optimum level of backup power from theory. The optimal demand for back-up power, assuming an exponential function for losses, is:

$$G^* = EXe^{\wedge}\left(-\frac{\lambda P}{\pi}\right) \qquad (3)$$

G* = optimum level of backup load, E= total electrical load, λ is the mean value of a loss, P is the price per kWh of unsupplied power, and π is the proportion of the year where power is not supplied.

According to the above model, the demand for back-up power varies directly with load, directly with the unreliability of the power grid and inversely with the cost of back-up power.

The ultimate loss may be inferred from Beenstock, Goldin, and Haitovsky (1997) loss function:

$$L = \ln\left(\frac{E\_i}{G\_i}\right) X\ 1/\lambda\_1 \qquad (4)$$

Where variables are the same in equation 3. Note: equation 4 is undefined when the firms lacks backup generator.

The variance of the electrical loss is a subset of the error term similar to stochastic frontier models. Thus, the loss function is not linear with respect to the aggregate duration of outages. The cost of self-generation is reported as three times as high as the subsidized cost of grid power in Africa (UNIDO, 2016). This eventually increases cost of production. The costs of losses exceed the marginal revenue production of labour and capital. Economic losses from electricity outages with respect to productivity appear to have a quadratic rather than linear form.

Gravity Model

Trade equations require the addition of gravity model variables to avoid the omitted variable bias and endogeneity with the error term (Chaney 2013). Gravity models have been used in economic geography to model domestic trade. The gravity trade model states that trade between two countries is proportional to product of the two countries' sizes and inversely with the distance between countries.

The general form of the gravity model is represented as:

$$T_{A,B} = (GDP_A X GDP_B) \div Dist^{Y}_{A,B} \qquad (5)$$

$T_{A,B}$ is trade between countries A&B, GDP_A represent GDP of country A and GDP_B represent GDP of country B, $Dist_{A.B}$ is the distance between country A and B.

Empirical work shows that the distance exponent Y is typically near 1, as are the exponents on GDP of countries (Chaney 2013). Distances between trading partners are measured between capital cities. The indices of mass in the model consist of GDP, GDP per capita, and population. The GDP variable represents the numerator in the gravity equation.

Stochastic Frontier Analysis

Production theory assumes that producers efficiently allocate inputs to maximize profits and therefore operate on the production possibilities frontier at equilibrium (Varian 2010). Bee (2016), argues that, disruptions in manufacturing production due to electrical outages and shortages are significant sources of inefficiency in manufacturing in LDCs. A further claim is that electrical outages decrease the net export component of GDP in LDCs by shifting supply chain and customer choices of manufacturers.

SFA models assume that production outputs are endogenous and inputs are exogenous (Kumbhakar 2015) because output is the choice variable in production while inputs are fixed in the short-term. Bee (2016) argues that, despite electricity's share of production costs, it's a significant factor in manufacturing production. The role of infrastructure, like electricity, is underestimated using production theory. Outages of electricity increase labour costs for firms without standby power while they decrease manufacturing exports of all manufacturing firms. Outages have spill overs from distorted trade that affect global welfare as well as domestic welfare. While standby power clearly moderates the effects of outages on lost production, the side effects include higher consumption of energy in production plus higher labour content. The estimates from Stochastic Frontier models indicate that electrical outages represent a substantial share of technical inefficiency in LDCs.

The Cobb-Douglass Production Function

The Cobb-Douglas is a simplest production function (Varian 2010). The power function uses a multiplicative relationship among variables to explain production. Econometric issues such as multicollinearity increase substantially with the use of a power form functions (Pavelescu 2016). Earlier research in Africa made greater use of the Cobb-Douglas production function with World Bank Enterprise Survey data (Escribano, Guasch and Pena 2010). Substitution and complementary effects between production inputs that have been identified in the literature can be incorporated into the C-D framework by the use of interaction terms. The common form of substitutions is electricity and labour. Thus complementarity of electricity and new capital investment with TFP. We adopted the Cobb-Douglas production function and modified it to develop our theoretical model in our study. Cobb-Douglass model can be represented in a simple production function as below:

$$Y(L,K) = AL^{\alpha}K^{\beta-1} \qquad (6)$$

Empirical Literature

The first relevant study on energy and growth dates to the late 1970s. In their pioneering work, Kraft and Kraft (1978) studied the relationship between gross national product (GNP) and gross energy inputs. They employed the Sims causality test procedure to infer causal relationship, and discovered that increased GNP leads to increased energy consumption. This approach has been largely criticised of its inability to capture inherent time series data issues such as endogeneity and non-stationarity of the variables. Several studies have applied the ARDL bounds test in the energy-GDP literature Narayan (2005) and (Gosh, 2009). There are few number of works that have applied the Toda-Yamamoto Distributed Lag (TYDL) approach to Granger Causality Tang (2008) and Wolde-Rafael (2009).

The Granger-causality test method has been argued as better alternative technique over the rest because of the favourable Monte Carlo evidence reported by Geweke, Meese and Dent (1983) particularly for small samples in empirical works. To conduct the Granger-causality test, a series of variables need to be stationary. It has been shown that using non-stationary data in causality tests can yield spurious causality results (Stock, 1989). But several studies are based on the bivariate model, which includes only energy and output or employment, as per Masih and Masih (1996), Soytas and Sari (2003), Yoo (2005), Yoo and Jung (2005), Chen et al. (2007) and Zachariadis (2007). The first attempt to investigate the direction of causality was proposed by Granger (1969). The Granger causality test is a convenient and very general approach for detecting presence of causal relationship between two variables. A time-series (X) is said to Granger-cause another time-series (Y) if the prediction error of current Y declines by using past values of X in addition to past values of Y (Granger, 1969). Testing for Granger-causality between two variables X and Y, involves specification of two bivariate models of X and Y. After a first difference, if two no stationary variables become stationary then the standard form of Granger causality is used to determine causality. Consequently, X is said to explain some variation of Y that is not explain by lagged values of Y if there is significant estimated coefficient on the lagged values of X. That is X Granger Cause Y. The causal results are sensitive to the lag structure of the independent variables (Engle & Granger, 1987). The arbitrariness in choosing lags can distort the estimates and yield misleading causality inferences (Lean & Smyth, 2010).

While the Granger and Johansen cointegration procedures and corresponding error-correction models have been widely used to study a causal relationship between energy consumption and economic growth, these methods have been criticized owing to the low power and size properties of small samples associated with conventional unit root and cointegration tests (Harris and Sollis, 2003). In response, more recent studies have employed the autoregressive distributed lag (ARDL) model and bounds testing approach Pesaran (2001), together with the Toda-Yamamoto (1995) and Dolado-Lütkepohl (1996) long-run causality tests, which can be performed irrespective of whether the variables possess a unit root and whether cointegration exists among the variables.

Altinay and Karagol (2005) used the Dolado-Lütkepohl test of long-run causality between electricity consumption and real GDP for the case of Turkey and found unidirectional causality, with increased electricity consumption leading to higher GDP. We choose to use the Autoregressive Distributed Lag (ARDL) bounds test for cointegration, proposed by Pesaran et al. (2001). There are good number of advantages of using the ARDL bounds test over alternative approaches to cointegration such as those proposed by Johansen. First, the ARDL bounds test can be applied irrespective of whether the variables are integrated of order zero I (0) or integrated of order one I (1) (Pesaran, 2001). Second, the ARDL bounds test has good statistical properties for small sample sizes of 30 to 80 observations, which is suitable for our case of 32 observations (Pesaran, 2001).

Lee (2005) employed the Toda-Yamamoto causality test and found no causal relationship between energy usage and real GDP per capita in Germany, Sweden and the United Kingdom; bidirectional causality between the two variables in the United States; increased energy consumption leading to increases in real GDP per capita in Belgium, Canada and Switzerland; and increases in real GDP per capita leading to greater energy consumption in France, Italy and Japan. Soytas and Sari (2003) also used the Toda-Yamamoto causality test for their model including energy usage, real GDP, real gross fixed capital formation and labour force variables to discover the causal relationship between energy consumption and growth in China. Their result irrespective of whether the variables possess a unit root and whether cointegration exists among the variables.

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Using employment to substitute for economic growth, Akarca and Long (1980) showed that increased energy consumption leads to higher levels of employment. However, when Sims causality test was used with different data set on U.S. from 1950 to 1970, Akarca and Long (1980) found no causal relationship between energy consumption and GNP. Similar findings were made by Erol and Yu (1987a), together with Murray and Nan (1992), using employment to substitute for economic growth.

Erol and Yu (1987) applied the Sims causality technique to monthly U.S data from 1973 to 1984 with varied variables in a bivariate model and found mixed causal relationships between energy consumption, GNP and employment. The model specification in the above studies was reliant on bivariate causality test of energy consumption and output or employment. However, a common problem of a bivariate analysis is the possibility of omitted variables bias, which could result in misleading statistical results Stern (2011) and (Payne & Apergis, 2010). Wolde-Rufael (2005), recognised the limitations of this approach and incorporated additional variables in their analyses for a panel study in Africa. Erol and Yu (1987) included employment when examining the relationship between energy consumption and GNP. Stern (1993) incorporated employment and capital in the analysis and found that increased energy consumption results in growth in real GDP.

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There is a sizeable literature on Granger causality between GDP and energy use for a range of countries using various methodologies. This literature has tested four competing hypotheses. These hypotheses are that there is unidirectional Granger causality running from electricity generation to GDP (growth hypothesis); unidirectional Granger causality running from GDP to electricity generation (conservation hypothesis); bidirectional Granger causality between these variables (feedback hypothesis) or no Granger causality in either direction (neutrality hypothesis) (Yoo, 2006).

Consensus has not been established in literature on these hypotheses and that the results are often conflicting. As Ozturk (2011), notes that, the topic of causal relationship between energy consumption and growth have been substantially examined in the energy economics literature. Different studies have focused on different countries, time periods, proxy variables and different econometric methodologies have been used to model the energy consumption and growth relationship. The empirical outcomes of these studies have been varied and sometimes found to be conflicting. These diverse results arise due to different data sets, alternative econometric methodologies and different countries' characteristics (Smyth et al., 2010). The actual causality is different in different countries and this might be due to countries' specific characteristics such as different indigenous energy supplies, different political and economic histories, different political arrangements, different institutional arrangements, different cultures and different energy policies (Bayraktutan et al., 2011). Mehrara (2007) reaches the same conclusion as Ozturk (2011), stating, "When it comes to whether energy use is a result of, or a perquisite for, economic growth, there are no clear trends in the literature." Depending on the methodology used, and country and time studied, the direction of causality between energy consumption and economic variables has remained empirically elusive and controversial (Smyth et al., 2009).

Payne (2010) calculates support for the competing hypotheses in studies published up until 2009. He concludes that 31.15 per cent of studies support the neutrality hypothesis, 27.87 per cent support the conservation hypothesis; 22.95 per cent support the growth hypothesis and 18.03 per cent support the feedback hypothesis. Hence, support for the competing hypotheses in the energy consumption-economic growth literature is evenly divided, and that create a lot of room for country specific probes to be made.

Results of the studies utilizing the Engle-Granger cointegration and error-correction model following Lee (2005) found that there is bidirectional causality between energy consumption and real GDP in South Korea and Singapore. Yet Cheng and Lai (1997) demonstrated unidirectional relationship from energy consumption to employment and from real GDP to energy consumption in Taiwan. Considering the possibility of omitted-variable biases, Paul and Bhattacharya (2004) and Pirlogea and Cicea (2012) all incorporated measures of either capital or labour or both in the context of a production model framework. Glasure and Lee (1995) included wages and energy prices and later wages, energy prices, real money supply and real government spending into their models to examine the relationship between energy consumption and growth (Glasure and Lee, 1996). Yu and Jin (1992) and Cheng (1997) found no long-term cointegration relation and no causal relationship between the two, while Glasure and Lee (1996) and Paul and Bhattacharya (2004), in contrast, found bidirectional relationship between energy consumption and growth. Bowden and Payne (2010) also studied the causal relationship between the disaggregated measure of energy consumption by sector and real GDP in the United States using the Toda-Yamamoto causality test.

Most of these studies have focused on the causal relationship between energy consumption and economic growth using aggregate energy consumption data. Given that the use of aggregate energy consumption could mask the differential impact associated with various types of energy consumption, as well as by end use and sector, Yang (2000a), Yoo and Kim (2006), Jinke (2008) and Pirlogea and Cicea (2012) attempted to examine the impact of various disaggregated measures of energy consumption such as electricity, coal, natural gas, oil and renewables, as well as by sector. The overall findings showed that there was a strong relationship between electricity consumption and economic growth (Furgason, Wilson & Hill, 2000). Interestingly, there are several findings supporting the bidirectional or unidirectional causality between electricity consumption and economic growth (Yang, 2000), (Gosh, 2002), (Shiu & Lam, 2004) and (Yoo, 2005). The relationship may very well run from electricity generation to economic growth, and from economic growth to electricity generation (Furgason et al., 200). Evidence on either side shall have a significant bearing upon policy. Generally, electricity improves the productivity of capital, labour, and various other factors of production. More importantly, extreme use of information and communications technologies is causing a worldwide shift towards a digital society (Shahban & Lean, 2012). These shifts will require further electricity generation (Baer et al., 2002).

Again, there is no consensus on the causal relationship between the two factors within and across countries. Johansen-Juselius cointegration and error-correction model has been more widely employed. Other studies included measures of capital and labour, as per Stern (2011), Hali and El- Sakka (2004), Oh, Pang and Chua (2010), Paul and Bhattacharya (2004), Soytas and Sari (2007, 2009), Yuan et al. (2008) or ii) consumer prices, as per Masih and Masih (1997, 1998) and Asafu-Adjaye (2007). Glasure et al. (2002), however, incorporated various variables, including real government expenditure, real money supply, real oil prices and dummy variable oil price shocks. While most of the studies have used aggregate energy consumption data, Ghosh (2002), Shiu and Lam (2004), Yoo (2005, 2006), Chen et al (2007), Soytas and Sari (2007), Zachariadis (2007) and Yuan et al. (2008) all employed various disaggregated measures of energy consumption by source and by sector.

Inconsistent and contradictory results are still reported across studies. For example, Masih and Masih (1997) found no causal relationship between energy consumption and growth in Malaysia, Singapore and the Philippines, while there was a bidirectional relationship between the two variables in Pakistan, South Korea and Taiwan. In addition, they found that increased energy consumption causes growth in India, Thailand and Sri Lanka, while economic growth leads to increased energy consumption in Indonesia (Masih & Masih, 1997).

Earlier studies using Australian data to examine the causal relationship between energy consumption and economic growth are based primarily on bivariate models. Using a bivariate approach, Fatai et al. (2004) applied different time series econometric methods (Toda-Yamamoto causality, ARDL bounds test, and Johansen-Juselius procedure) to annual data from 1960 to 1999, and concluded that real GDP growth leads to increased energy consumption. Narayan and Smyth (2005), by way of contrast, used a three variables model (electricity consumption per capita, real GDP per capita, and manufacturing employment index) and applied ARDL bounds test to discover the causality relationship. The results also showed that there is unidirectional causality, with growth leading to increased electricity consumption (Narayan & Smyth, 2005). Using a bivariate model and Johansen-Juselius test procedure, Yuan, Zhao, Yu and Hu (2008) demonstrated causality from real per capita GDP to per capita energy consumption for the period 1960-2000. These test results contradict with those of Narayan and Prasad (2008), who found a long-run causality from electricity consumption to output in Australia for the period 1960–2002 using a bootstrapped Granger causality test.

Stern (2011) found that greater energy consumption results in growth in the United States, while Soytas and Sari (2003) discovered no causal relationship in Canada, Indonesia, Poland, the United Kingdom, and the United States; bidirectional causality in Argentina and Turkey; unidirectional causality with greater energy consumption leading to increased GDP in France, West Germany and Japan; and causality with increased GDP leading to increased energy consumption in Italy and South Korea. In contrast to Soytas and Sari's result (2003), Ghali and El-Sakka (2004) established bidirectional relationship between energy consumption and growth in Canada. Finally, Oh et al. (2010) found inconsistent conclusions for the case of Korea when using different data sets and models.

They incorporated real gross fixed capital formation and employment variables in their analysis and found no causal relationship between industrial renewable energy consumption and real GDP; bidirectional causality between residential non-renewable energy consumption and real GDP; and unidirectional causality with residential industrial non-renewable energy consumption leading to an increase in real GDP (Narayan & Singh, 2007). Another study in U.S by Sari et al. (2008) included employment variable and employed the ARDL bounds test to investigate the causal relationship between the disaggregated measures of energy consumption by sources and industrial production. The results showed unidirectional causality, with increased industrial production leading to greater energy consumption, except for the case of coal consumption, which was found to lead growth (Sari et al., 2008). Another approach that addresses the concerns of the low power and size properties of small samples associated with conventional unit root and cointegration tests is the panel cointegration tests. Panel unit root and cointegration tests provide additional power by combining the cross-section and time series data allowing for the heterogeneity across countries (Payne, 2010). Lee (2005), Chen et al. (2007), Mehrara (2007), Narayan and Smyth (2007), Lee and Chang (2008), Zachariadis, T. (2007) employed this approach, while Huang, Hwang and Yang (2008) and Sharma (2010) applied dynamic panel estimation to infer a causal relationship between energy consumption and economic growth.

Lee (2005) included real gross capital formation in the analysis and found unidirectional causality, with increased energy consumption leading to real GDP growth for developing countries panel. Yet Chen et al. (2007) discovered bidirectional causality between electricity consumption and real GDP for a ten-country panel including China, Hong Kong, Indonesia, India, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand. Mehrara (2007), however, found that real GDP per capita growth led to an increase in commercial energy usage per capita for the oil-exporting countries panel. Narayan and Smyth (2007) included real gross fixed capital formation in the estimation and found that energy consumption per capita causes real GDP growth per capita for the G7 panel.

Lee et al. (2008) in a study in the OECD countries, found bidirectional causality between the electricity generation and growth variables, while Lee and Chang (2008) incorporated both real gross fixed capital formation and labour force and found unidirectional causality, with increased energy consumption leading to real GDP growth for the Asian panel and APEC panel. Huang et al. (2008) classified data into four income groups and discovered i) no causal relationship between energy consumption and real GDP per capita for the low-income panel, ii) economic growth leading energy consumption positively in the middle-income group and iii) economic growth leading energy consumption negatively for the high-income panel. Mixed results on the impact of electricity and non-electricity consumption on economic growth for a global panel as well as for four regional panels (East/South Asian and the Pacific region, Europe and Central Asian region, Latin America and Caribbean region, and Sub-Saharan, North Africa and Middle Eastern region) were also found by Sharma (2010). The analysis was based on a model consisting of inflation, capital stock, labour force, trade, and energy.

To reduce potential omitted-variable biases, Mahadevan and Asafu-Adjaye (2007) included consumer price index as a third variable in their study. They found evidence of cointegration and bidirectional causality between per capita energy consumption and real per capita GDP for the period 1971-2002. Rashid and Alam (2012) incorporated capital and labour in their study, in addition to energy consumption and real GDP, and used both Johansen- Juselius and Toda-Yamamoto causality tests and found a bidirectional causal relationship in Nigeria. They also found evidence of cointegration and bidirectional causality between GDP and energy usage, which is consistent with the results of Mahadevan and Asafu-Adjaye (2007).

The extension of Yoo and Kim's (2006), work by Sarker (2010), by studying electricity generation and economic growth yielded strong economic relationships in Bangladish. Bayraktutan et al. (2011) examined the relationship between electricity generation from renewable sources and economic growth on OECD countries and found a long tern positive relationship between renewable electricity generation and economic growth with bidirectional causality between these variables but (Lean and Smith, 2010) have been the first in literature to widen the scope of these dynamics to include electricity generation, economic growth, exports and prices in a multivariate model for Malaysia. This work will further deepen literature by looking at the specific case of manufacturing, services, exports, capital and degree of urbanisation and growth in Ghana.

An analysis of the relationship between electricity generation from renewable sources and economic growth in OECD countries resulted in long term positive relationship between renewable electricity generation and economic growth with bidirectional causality between the two variables. Lean and Smyth, (2010) contributed to literature in Malaysia by interacting electricity generation, economic growth, exports and prices in a multivariate model for Malaysia. Evidence on the electricity generation and economic growth shall have significant bearing on policy formulation for both growth and electricity generation. For instance, if there is unidirectional causality running from electricity generation to economic growth, reducing electricity generation could lead to a decrease in economic growth. Also, a unidirectional causality running from economic growth to electricity generation implies policies for reducing electricity generation may have little or no effects on growth (Pual et al., 2004). Consequently, no causality in both direction would mean that policies calls for more electricity generation has no effect on economic growth (Narayan et al., 2008).

Soytas and Sari (2007), argued that no uniformity in empirical results could be adduced to different economic structure of countries as different economies have different consumption patterns and electricity generation capacities. These observations make it more relevant to experiment on a small economy like Ghana as our policy directions have not been clearly defined in terms of services and manufacturing. A unidirectional Granger causality or no causality in either direction that runs from GDP to electricity generation would mean that, energy conservation policies have little or no adverse effect on economic growth (Tang and Tan, 2013).

The second group of competing hypotheses concerns causality between exports and GDP (Zachariadis, 2007). The export led hypothesis have it that Granger causality runs from exports to growth (Yuan et al., 2007). This results is explained by several reasons. Obviously, exports lead to growth because exports are a component GDP accounting (Zachariadis, 2007). Also, countries with high export GDP ratio generate more externalities due to its high level of interactions with other economies (Yuan et al., 2007). Lean and Smyth (2010), concluded that economic growth has increase electricity generation in Malaysia.

Causal relationship between electricity generation and economic growth has been rarely investigated in literature. There could be any possibility, the relationship may run from electricity generation to economic growth and from economic growth to electricity generation or both (Narayan et al., 2005). Yoo and Kim (2006), found a unidirectional causality from economic growth to electricity generation without feedback effect. Apparently, economic growth stimulates further electricity generation, and policies for reducing electricity generation can be initiated without deteriorating economic side effects in Indonesia (Yoo and Kim, 2006).

Yoo and Kim (2006), found the existence of a long-run relationship between electricity generation and real GDP in Indonesia. They also found results of cointegration between electricity generation and growth. Yoo and Kim (2006) also found Granger causality phenomena between economic growth and electricity generation in Indonesia. Economic growth was also found to affect electricity consumption for Indonesia (Yoo & Kim, 2006). Generally, they found existence of a unidirectional causality resulting from economic growth to electricity generation without any feedback effect for Indonesia.

The driving aims of electricity conservation is to reduce the need for electricity without limiting consumption benefits (Yoo, 2005). An absence of a unidirectional causality running from electricity generation to economic growth in the country has important policy derivatives for policy makers, because electricity conservation policies through rationalizing the tariff structure, efficiency improvement and demand side management, which aim at curtailing waste of electricity and thereby reducing the electricity generation without affecting the end-use benefits, can be initiated without inflicting damaging effects on the economic growth of the country (Smyth, 2010).

We think of this work as the beginning of a long-term effort to completely disclose causal linkages between electricity generation and economic growth in Ghana. Such an analysis could reveal the structural channels by which real income and electricity generation are inherently linked (Sarka, 2010). We have the conviction that as better data becomes available, further analysis can be done on the causality between electricity generation and economic growth in Ghana.

Smyth (2010) argues that including electricity generation, exports, economic growth and prices in one model effectively marries the Granger causality literatures on the energy-GDP catena and exports-GDP catena. This follows the approach in Narayan & Smyth (2009) which is a panel data study for the Middle East. In that study, Narayan and Smyth (2009) suggested that a natural extension of their work, would be to look at the relationship between energy, exports and GDP in the export- oriented high growth Asian economies.

As developing countries poised to grow, it is reasonable to understand transmission mechanisms for informed policy direction since we have competitive advantage in both services and manufacturing sectors. Lean and Smyth (2009) consider Granger causality between economic growth, exports and electricity consumption for Malaysia; however, they use electricity consumption rather than electricity generation. We have established in literature that our generation loss is 3.8% which is within acceptable range and communicate appropriately for a developing country. This choice of variables may be giving a developing economy like Ghana clear understanding of the options available.

Several arguments are raised in literature to show that, countries that have move from low income status to middle income countries did so by investing in industrialization of the manufacturing and construction sectors as major driving forces of their economies (Anaman & Osei-Amponshah, 2009). Osei-Amponsah and Anaman (2008), established Granger Causality from economic growth to manufacturing but however found no Granger Causality running from manufacturing to economic growth. Thus, there was unidirectional causality from economic growth to manufacturing. But Adom and Kwakwa (2014), found contrasting result of 1% expansion of the manufacturing sector to increase Ghana's energy intensity by approximately 3%. Thus, expansion in the generation of electricity can drive the manufacturing sector of the Ghanaian economy. The results are not also consistent with the results of Lean and Smith (2010), who found in Malaysia that growth in manufacturing lead to demand for electricity.

The government of Ghana established policies to boost private sector development to improve investment and accelerate basic service delivery as necessary factors to expand and sustain business growth, stimulate economic growth and reduce poverty (Accad et al., 2014). Despite all the efforts, output from private sector has not been impressive evident in wading performance of the industrial manufacturing sector (Anaman & Osei-Amponsah, 2009). The contribution of the manufacturing industry continues to fade attributable to factors such as high cost of production, the influx of relatively cheaper substitute from Asia and the other parts of the world (Anaman & Osei-Amponsah, 2009). Factors that limit the potential of African manufacturing firms in creating export value are their levels of efficiency and size (Soderbom & Teal, 2003). Narayan and Singh (2007), agreed to this phenomenon and made the case that services sectors such as software, business processing, finance or tourism may act as leading sectors in development and that the role of manufacturing is declining. Adom and Kwakwa (2013), concluded that a 1% expansion of the manufacturing sector will increase Ghana's energy intensity by approximately 3%. This phenomenon show that as electricity consumption reduces we expect manufacturing to fall causing a fall in growth.

The collapse of manufacturing exports has been a common factor that accounted for the collapse of African economies (Van Biesebroeck, 2005). Soderbom and Teal, (2003) in a cross-country study found long run stagnation of manufacturing growth in South Africa, and a long run failure in Zambia but found a higher manufacturing growth in Botswana and Mauritius. They however found that Ghana, Tanzania and Uganda had a general pattern of contraction in the manufacturing sector. Adom and Kwakwa (2014) argued that activities of the manufacturing sector are highly energy driven, which implies that further expansion in the scale of manufacturing activities in Ghana will spur energy demand pressures. Consequently, energy intensity increases.

A changing production mix and technical characteristics of manufacturing sector improved energy efficiency (Adom & Kwakwa, 2014).

African countries generally take longer periods to rise in manufacturing growth. Ghana (1975), South Africa (1980), Botswana (1985), Kenya (1985), Egypt (1990), Tanzania (1990), Nigeria (1995), and Uganda (1995) are examples. Sirmai and Vaspergen (2005) found interaction between manufacturing and relative GDP per capita to be negative in a cross country study of selected African countries. Eichengreen and Gupta (2011) pointed out that service sector's contribution to GDP has increased steadily over time and it has established. Bhattacharya and Mitra (1997) realised that the impact of per capita income on the percentage share of tertiary sector in total work force was positive, though it tended to stabilize at higher stages of development. Jane (2011) identified for instance in India, the importance of services as an input to production in the manufacturing sector increased considerably in the nineties compared to the eighties. Eichengreen and Gupta, (2011) concluded that the share of services in national product did not vary significantly with per capita income. Chenery (1960), when regressing the share of services on per capita income, found an insignificant coefficient on the latter, concluding that the relationship between services and per capita income is not uniform across countries. Kongsamut, Rebelo and Xiao (1999) realised a contrasting result in the share of services in output to be linear with per capita income. Jensen et al. (2005), calculate the Gini Coefficient for the geographical dispersion of each activity and use it to identify tradable and non-tradable services.

Lee and Wolpin (2006) analysed the growth rate of GDP on share of services in employment. They found negative and significant coefficient suggesting that relative increase of the services' share in employment is associated with a decline in the output growth rate. Linden and Mahmood (2007) studied the long run relationship between sectors' share and economic growth using panel data and found out that the relationship between services share growth and growth rate of GDP per capita was bidirectional.

Conclusion

The study of electricity generation and economic growth is an emerging trend in literature. The use of multiple variables is a common procedure in literature to study the relationship between electricity supply and economic growth. Multivariate procedure can avoid specification bias due to omission of relevant variables. Though Toda-Yamamoto and Dolado-Lutkepohl are suitable substitutes, we chose to use ARDL and Granger Causality methods. An ARDL approach is not affected by the order of integration of the variables and sample size. While Granger and Johansen cointegration are available, these methods have been criticised to have low power and unable to well capture small size properties of small samples associated with conventional unit roots and cointegration test.

We have also established in literature that, variation in empirical findings could be because of different economic structures. It is important we examine the specific case of Ghana using a robust statistical tool since our sample size is only 32 observations.

CHAPTER THREE

METHODOLOGY

Introduction

We appreciate the need for proper influence of various transmission mechanisms from electricity energy to economic growth. We examine the methodology of both the theoretical and empirical model of the study under this chapter. Detailed description of research design, theoretical and empirical models used for the study including an extensive discussions of the variables and estimation techniques are presented in this chapter.

The Research Design

The quantitative research design is employed to investigate the research hypotheses of the study. The entire study subscribes to the positivist philosophy of rationality. It argues that only scientific knowledge can establish the truth about reality. Positivist sought to construct a unified scientific world conception that rejects the use of philosophy as a means of learning about the true nature of reality. Positivists emphasise on observable facts of validity, reliability, objectivity, precision and generalizability to explain quantitative studies intended to describe, predict and verify empirical relationships in relatively controlled environment (Wooldridge, 2011). The positivist argues that real events can be observed empirically and explained with logical analysis, which the study seeks to do.

The concept of research design may include processes from conceptualization of a problem to the literature review, research questions, methods and conclusions or may simply be the methodology of a study (Harwell et al, 2010). Our study is a time series analysis with positivist philosophical orientation and drives its economic theory from the neoclassical school of thought.

Theoretical Model Specification

To establish the relationship between electricity generation and economic growth, the study adapted the neoclassical growth model of Solow model (1956). A simplified view of the economy in which production output is determined by the amount of labour involved and the amount of capital invested (Tang, 2008).

$$Y(L, K) = AL^{\alpha}K^{\beta-1} \quad (6)$$

Y = output, K = capital stock, L = labour force, A is technology progress

Output elasticity measures the responsiveness of output to a change in levels of either labour or capital used in production, ceteris paribus. Let's assume that $\alpha>0$ and $\beta>0$, where $A>0$ represent total factor productivity and $0<\beta<1$

Assuming technological progress is labour augmenting of the form;

$$\Rightarrow Y_t = f(k_t AL_t) \quad (7)$$

Then it is defined as Harrod-neutral and represented in per capita terms as;

$$Y = A\left(\frac{K}{L}\right)_L^{\propto} = AK^{\propto}L \quad (8)$$

$$\Longrightarrow Y = AK^{\propto} \quad (9)$$

- Y measures manufacturing per capita GDP of the economy at time *t*,
- K measures the aggregate capital stock in the economy at time *t*, measured as gross fixed capital formation

- A Represents total factor productivity (TFP) at time *t*. Total factor productivity is the part of output not explained by the quantity of inputs used in production (Comin, 2006). It is usually a measure of degree of technological advancement that complements economic growth.
- α is the coefficient of elasticity for capital.

Barro and Sala-i-Martin (1995) show that technological progress can always be expressed as labour augmenting. They proved mathematically that only labour-augmenting technological change is consistent with the existence of a steady state.

Empirical Model Specification

In existing literature, traditional OLS method is usually used to estimate parameters and to conduct statistical tests. These traditional estimation methods do not take into consideration the special features of time series data, such as endogeneity of regresses and the non-stationarity of the variables, both of which could result in spurious regressions and eventually leads to misleading statistical results (Granger and Newbold, 1974).

With continual advances in time series econometrics, new time series econometric techniques such as Granger (1987) and Johansen (1990) cointegration and error-correction models have been developed and applied to re-investigate the relationship between energy consumption and growth. While the Granger and Johansen cointegration procedures and corresponding error-correction models have been widely used to study the causal relationship between energy consumption and economic growth, these methods have been criticized owing to the low power and size properties of small samples associated with conventional unit root and cointegration tests (Harris and Sollis, 2003). In response, more recent studies have employed the autoregressive distributed lag (ARDL) model and bounds testing approach, together with the Toda-Yamamoto (1995) and Dolado-Lütkepohl (1996) long-run causality tests, which can be performed irrespective of whether the variables possess a unit root and whether cointegration exists among the variables.

Altinay and Karagol (2005) used the Dolado-Lütkepohl test of long-run causality between electricity consumption and real GDP for the case of Turkey and found unidirectional causality, with increased electricity consumption leading to higher GDP. We choose to employ autoregressive distributed lag model ARDL in our study.

In this study, we assume total factor productivity (A) as a function of Electricity Generation (ECG), Services (SG), Manufacturing (MG), Exports (EX) and Degree of Urbanisation (DU) as well as other exogenous factors (C). The functional form of the technological progress is given as in equation

$$A_t = f(ECG_t, SG_t, MG_t, EX_t, DU_t) \qquad (10a)$$

$$A_t = ECG_t^{\beta 1} SG_t^{\beta 2} MG_t^{\beta 3} EX_t^{\beta 4} DU_t^{\beta 5} C_t \qquad (10b)$$

Equation (10b) is stated in functional form where A_t is TFP at time t. Equation 10b represent sectors of the economy that explains total output in our model. The rest of term are defined as:

- ECG_t = electricity generated per capita at time t, measured as the quantity of electricity generated divided by the total population to power economic activities as recorded in the
- MG_t = measures manufacturing, value addition of per capita GDP in constant US dollars 2010.
- SG_t = services sector value addition as percentage of GDP.
- EX_t = Exports of goods and services as percentage of GDP.
- DU_t = Degree of urbanisation, which measures the rate at which urban population grows
- C_t = other exogenous variables

Combining equations 9 and 10b, will result equation 11 as illustrated below.

$$Y_t = ECG_t^{\beta_1} SG_t^{\beta_2} MG_t^{\beta_3} EX_t^{\beta_4} DU_t^{\beta_5} CAP_t^{\alpha} \qquad (11)$$

To linearize the variables and express the elasticity of the variables, we proceed to take natural logarithm of all variables in equation 11 to yield equation 12 below;

$$\ln Y_t = \beta_1 \text{InECG}_t + \beta_2 \ln SG_t + \beta_3 \ln MG_t + \beta_4 \ln EX_t + \beta_5 \ln DU_t + \alpha \ln CAP_t + \varepsilon_t \qquad (12)$$

where $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ *and* α, are constant elasticity coefficients with respect to ECG_t, SG_t MG_t EX_t CAP_t and DU_t is a constant parameter, ε_t is the white noise error term, *t* represent time and ln represents natural logarithm.

We now express the production function in equation 12 as a growth model for purposes of achieving our objectives;

$$\Delta \ln Y_t = \beta_1 \Delta \ln ECG_t + \beta_2 \Delta \ln SG_t + \beta_3 \Delta \ln MG_t + \beta_4 \Delta \ln EX_t + \alpha \Delta \ln CAP_t + \delta \Delta \ln DU_t + \varepsilon_t \quad (13)$$

Equation 13 is the long run model and if it is valid, cointegration equation will have equivalent short run error correction model (ECM).

Yoo and Kim found a unidirectional causality from economic growth to electricity generation without feedback effect. Apparently (2006). Altintas and Kum, (2013), by using time series data from 1970 to 2010, concluded there was a bidirectional relationship between economic growth and electricity generation in Turkey. The finding establishes feedback hypotheses for Turkey. Manufacturing sector is known to drive economic growth in Turkey and consumes more of the electricity produced in Turkey. A reduction in electricity generation will affect economic growth negatively (Altintas and Kum, 2013).

Singh (2006), found that services growth stimulated faster economic growth in India and concluded that services growth is the new reality to fight poverty in developing countries. Also, growth in the service sector was found to be cointegrate with poverty reduction than growth in agriculture for a sample of 50 developing countries (Ghani et al., 2011). Aryeetey and Kanbur (2005), found statistically significant negative effect of capital accumulation on economic growth.

Lean and Smyth (2010), found a unidirectional Granger causality running from economic growth to electricity generation. They found that neither the export-led nor handmaiden of trade were supported by the data in

Malaysia however, Altintas and Kum (2013), found a bidirectional Granger causality running from growth to export, validating the export-led theories of growth. Again, there was a bidirectional relationship between export and electricity generation. Based on this result, reduction in electricity generation stifles export expansion, an engine for economic growth, in Malaysia (Altintas & Kum, 2013). Energy conservation would create serious impedance on export growth in Malaysia.

The short-run model for the study is given as:

$$\Delta \ln Y_t = \beta_0 + \sum_{i=1}^{q} \beta_1 \Delta \ln ECG_{t-i} + \sum_{i=1}^{r} \beta_2 \Delta \ln SG_{t-i} + \sum_{i=1}^{s} \beta_3 \Delta \ln MG_{t-i} + \sum_{i=1}^{t} \beta_4 \Delta \ln EX_{t-i} + \sum_{i=1}^{u} \beta_5 \Delta \ln CAP_{t-i} + \sum_{i=1}^{v} \beta_6 \Delta \ln DU_{t-i} + \psi ECT_{t-1} + V_t \qquad (14)$$

Where ECG represent electricity generation, MG represent manufacturing value addition share of growth, SG represent share of services of the total growth, EX represent export value addition CAP represent capital accumulation, DU is the degree of urbanisation. The coefficients β1 β2, β3, β4, β5 and α measures elasticity of the variables respectively, where ψ shows the speed of adjustment, β0 is the drift float component, *t* denotes time and Vt is the stochastic error term.

A'Priori Expectations

Based on the review of literature, the a'priori signs of the variables are presented in the table below.

Table 1: Definition and A'Priori Signs of Variables

Variables	Definition of Variables	A'Priori
EG	Real GDP Per Capita	Positive
ECG	Electricity Generation Per Capita	Positive
MG	Manufacturing Per Capita	Positive
SG	Service Value Addition	Positive
EX	Exports Value Addition	Positive
CAP	Gross Capital Formation	Positive
DU	Rate of Urban Migration	Positive

Source: Author (2017)

Justification and Measurement of Variables

Economic Growth

Economic growth may be defined as an increase in a country's gross domestic product over a defined period. Existing literature supports measurement of economic growth using real GDP per capita. The rate of growth of GDP represent the pace of economic growth and this is where real GDP per capita becomes relevant. Real GDP per capita is the ratio of the total gross domestic product (GDP) and the total population of a given country. It is a unique way of measuring relative performance. Real GDP per capital is the GDP per person in the economy. GDP per capita is gross domestic product divided by midyear population (Birol, 2010). GDP per capita reflects changes in total wellbeing of the population (DeLuca, 2017). By allocating total production to each head of population, we can measure the extent to which total production of a country can be shared by its population (DeLuca, 2017).

Real GDP per capita is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (Birol, 2010). It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars (WDI, 2016). Boulhol, Serres and Molnar (2008), in their studies argued that, the use of real GDP per capita as a measure of economic growth, have contributed to a clearer understanding of the real channels of policy linkages between labour and product market outcomes in OECD countries. As a simple composite indicator, it is a powerful summary indicator of economic development (IMF, 2015). We expect growth influence in all sectors of the economy as the economy expands. The expected sign of growth is positive for our study.

Electricity Generation Per Capita

It is defined as the total amount of electricity produced annually as a ratio of total population in the same year. Electricity production is measured as the total electricity generated through hydropower, coal, oil, gas, and nuclear power generation, it covers generation by geothermal, solar, wind, tide and wave energy, as well as that from combustible renewables and waste (WDI, 2016). Production includes the output of electricity plants that are designed to produce electricity only as well as that of combined heat and power plants. In Ghana, major sources of generation include hydro, thermal, oil powered and solar.

Electricity generation is measured at the terminals of stations. Aside hydropower, gas and oil, it covers generation by solar, wind energy and combustible renewable energy (Kwakwa, 2012). Yoo and Kim (2011) measured electricity per capita as the total generation divided by total population in their study of the Malaysian economy. Electricity generation per capita was measured dividing total electricity generation over annual population in Turkey (Altintas & Kum, 2013). Clearly, literature supports quantity of electricity generated as the source of energy to power economic activities. We anticipate positive relationship between electricity generation and economic growth. The county's transfer and distribution losses are within acceptable range of 3.8% in 2015 (Electricity Commission, 2016). The use of electricity generation is justified in literature to communicate per capita generation requirements to meet the ever-growing population in developing countries (Sambo et al., 2012).

Manufacturing, Value Addition of Per Capita GDP

Manufacturing refers to industrial value addition in constant US dollars 2010. Value addition is the net output of a sector after adding up all outputs and subtracting intermediate inputs. Manufacturing is captured using product value addition in constant 2010 dollar values (WDI, 2016). It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources (WDI, 2016). The challenges of manufacturing policy makers in developing countries are basically to increase economic development to achieve industrialized economy, which encourages rise in consumption VanBiesebroeck (2005), and reducing manufacturing environmental impact is a serious challenge policy makers had to confront daily so long as manufacturing is a major derivative of energy intensity (Soytas, 2007).

It has also been argued in literature that the importance of manufacturing has fallen over the last 20-25 years resulting in destabilizing industrialization of developing countries largely attributable to long term dynamics in development of manufacturing sector's potential (Eshun & Amoako-Tuffour, 2016). This is attributable to failures of manufacturing development in many developing countries against a fall in rapid manufacturing development in a small number of developing countries (Van Biesebroeck, 2005). Haraguchi, Cheng and Smeets (2017) rejected these claims of shrinking opportunities for manufacturing development in developing countries and a decrease in the importance of manufacturing for their economic development. Even after 1990, conditions of manufacturing in developing countries still can drive economic development to achieve sustained growth (Haraguchi et al., 2017).

Ghana's real Gross Domestic Product (GDP) growth has been declining since 2012 (IMF, 2016). In a panel study, Escaith (2008) found industrial development as an important agent for economic growth in China. However, recent results of economic research pose critical questions concerning the continued importance of the manufacturing sector for economic development. Szirmai and Verspagen (2015) however found a moderate positive effect of manufacturing on economic growth. But after 1990, manufacturing was found becoming a more difficult channel to growth (Szirmai & Verspagen, 2015). Clearly, there exist a positive relationship between manufacturing value addition and economic growth.

Services

Services is defined as value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also admissible are evaluated bank service charges, import duties, and rescaling (WDI, 2016). Value added is the total output of a sector after summing up all outputs less intermediate inputs.

Services sector leads to growth in the Indian economy (Mishra, Gable & Anand, 2012). Innovation in business development and technology turn to dictate the nature of production frontiers for service activities. This has increased the share of services in GDP growth. For a decade now, services growth as a share of world's GDP, has been remarkably high and consistent, accounting for 70% of global growth and service exports in developing countries have almost tripled between 1997 and 2007 (Snow, 2017). The mid-1990s was characterised by two apparently separate but related developmental forces; the revolution in information and communication technology and speedy evolution in technology, transportability, and tradability (Ghani & Kharas, 2011).

There are increasing similarities in development between services and manufacturing goods as they both benefit from technological advancement and potential gains from specialization through economies of scale, agglomeration, network effects, and division of labour to build a robust economy (Mishra, 2012). Complex Services mostly require digital labour mobility, creating an opportunity for relatively innovative high-tech job creation in low and middle-income economies (UNIDO, 2016).

The emerging services revolution is highly electrical energy dependent (Yoo & Kim, 2006). For any policy choice to either expand growth through services or manufacturing, there is a need for steady electricity supply. We expect positive relationship between services growth and economic growth.

Capital

Capital is a major factor in determining aggregate output. We have measured capital in our work by gross capital formation or gross domestic investment consisting of expenditure in additions to the fixed assets of the economy plus net changes in the level of inventories (WDI, 2016). Capital accumulation is defined as the investment of financial assets for purposes of generating more assets.

Research in much of the last decades of the 20th century on the rapid growth of many developing countries points to their increased capital accumulation, labour skills and their managerial competencies (Financial Times, 2016). Capital accumulation is real investment in tangible means of production such as acquisitions, research and development etc. that increase capital flow to power further growth in other to reduce poverty (Ewubare & Ogbuagu, 2015). Economic growth is a derivative of policies that increase investments by increasing savings through efficient use of technological advancement (Becker et al., 2017). Ewura and Ogbuagu (2015), insisted that capital accumulation, human capital development, national savings rate, technological progress, and policies that ensures openness are accountable for long term economic growth.

Ugochukwu (2013) and Oriji and Mba (2010) established a positive effect of capital on growth rate of the Nigerian economy. However, there was no short and long run effects of capital accumulation, human capital development on economic growth (Ewubare & Ogbuagu, 2015). Ewubare and Ogbuagu (2015) concluded there was a negative and insignificant effect on economic growth with negative impulse on both short and long run.

Ferdinand (2013), found a strong positive correlation between investment in education, reduction of public sector debt and economic growth in Ghana. We expect a positive relationship between capital accumulation and economic growth.

Degree of Urban Migration

Degree of urbanisation is the rate at which urban population grows. Urbanization has been an integral component of economic growth and has advantaged the developing world benefit both from economic and demographic transformation with a complex development process (Marmara & Usman, 2015). Urbanization is the large movement of people from one rural country side to the affluent cities of the world (Todaro and Smith 2006). Urbanization can therefore be viewed as a population shift from rural to urban locations, and a measure of the ways in which society adapts to the change (Todaro et al, 2006). The link between rural-urban migration and urbanization however goes far beyond the supply of additional population to urban centres. Migration and urbanization are both the consequence of modernization of an economy historically connected with industrialization and economic growth (Bhattacharya et al., 1997). The concept of urbanization and economic growth coact, and no country has ever attained middle-incomes without urbanizing, and none has achieved high income without vibrant cities that are hubs of innovation, entrepreneurship and culture accounting for 70 percent of global GDP (EC, 2016). We anticipate a positive relationship between degree of urbanization and economic growth as our a priori expectation.

Source of Data

We relied on annual time series data for Ghana downloaded from the World Development Indicators database of the World Bank (2016). The study covers the period of 1983 to 2015. The electricity generation data was retrieved from Enerdata database of world energy information.

Estimation Techniques

We investigate the relationship between electricity generation and economic growth by applying ARDL (Pesaran et al, 2001) bound testing approach to cointegration. We first use the unit root test to check for order of integration using Augmented Dickey-Fuller (ADF) Mushtag (2011), and Philip-Perron (PP) test (Phillip & Perron, 1988). The purpose of unit root test is to check for stationarity of the variables (Pesaran et al., 2001). Once the order of integration is determined, we test if there is cointegration relationship between the variables with autoregressive distributed lags model (Mushtag, 2011). We further test whether there is a causal relationship between economic growth and electricity generation. Finally, we further test for residual and stability of our model (Pesaran et al., 2003).

Graphical Method of Test Stationarity

This method is used to check for unit root by plotting time profiles of variables in the model over the sample period 1983-2015 to examine the trends of the variables to detect whether they exhibit constant mean and variance. If the plotted time profile does not move around the mean, the observed movements suggest non-constant mean and variance. Per Harris (1995), this is evidence for either deterministic or stochastic trends. Figure 3, appendix A illustrates plots of variables at levels.

Unit Root Test

Times series data rarely exhibit stationarity at levels. Time series data are often found not to be stationary and usually leads to spurious results when used in regression analysis (Pesran, 2003). Spurious results will often lead to high and significant relationship among the variables when no relationship exist (Pesaran, 1995). A time series data is said to be stationary if the mean, variance and auto covariance does not depend on time. The conventional test statistic such as t, F, DW, and R^2 will lack standard distribution if some variables of the model have unit roots (Pesaran, 2003).

We first employ the unit root tests to ascertain the order of integration for each series. When there is non-stationary time series data then the method of differencing is applied to the series until stationarity is achieved

(Wooldridge, 2011). The Augmented Dicky-Fuller (Mushtag, 2011) and Phillips Peron test (PP, 1988) was used to test unit root of the variables. These tests are one-tailed test and skewed to the left and has a null hypothesis of unit root (non-stationary) against the alternative hypothesis of no unit root (stationarity) (Wooldridge, 2011). In each instance the lag length is determined using Akaike Information Criteria (AIC) (Akaike, 1969) and Swartz Information Criteria (SIC) Lindle, (2007), for both ADF and PP test. The ADF is very sensitive to lag selection making PP test an important extra tool for making statistical inferences about unit roots. The mathematical representation of ADF is

$$\Delta X_t = \varphi + \beta_1 + \phi X_{t-1} + \sum_{i=1}^{q} \alpha_i \Delta X_{t-i} + \upsilon_i \quad (15)$$

Where X_t denote time variation at time t, Δ is the difference operator, φ, ϕ, α are parameters to be estimated and υt is the stochastic random disturbance term.

We also employed PP test for unit root test because of the following reason. First, ADF test do not take an account of data with heteroskedasticity and non-normality that are usual features of time series data variables. Secondly, ADF is not able to distinguish between stationary and non-stationary series that have a high degree of autocorrelation. Finally, ADF is not able to handle circumstances of time series data with serial correlation and structural breaks (Wooldridge, 2011).

The assumption of the ADF is that the error terms are independent with constant variance while the assumption of the PP is that the error term are weakly dependent and heterogeneously distributed and thus provides robust estimates over ADF. The standard formula of PP is defined as;

$$\Delta X_t = \upsilon_{1i} + \alpha X_{t-i} + \rho\left(t - {}^{T}/_{2}\right) + \sum_{i=1}^{q} \rho_i \Delta_{t-i} + \upsilon_{2i} \quad (16)$$

υ_{1i} and υ_{2i} represent the covariance stationary random error terms. The hypothesis tested in both instances is as follows

H_0: Series contains unit roots

H_1: Series does not contain unit roots

The null hypothesis of unit root implies non-stationary against the alternative hypothesis of no unit roots, implies stationarity. The decision rule is that if ADF and PP statistic are higher, in absolute terms, than the critical values, we reject the null hypothesis and conclude that there is no unit root implying stationarity. But if the ADF and PP statistic are less negative than the critical values then we accept the null hypothesis and conclude that there is unit root indicating non-stationarity.

Cointegration Test

To appropriately correct for non-stationarity and unit root, first differencing is largely used. But first differencing usually leads to loss of long run relationship information which is of interest to an economist. Granger (1986) established a channel between non-stationarity processes and the concept of long run equilibrium. Variables are said to be cointegrated if they have a common trend (Pesaran et al., 1995). Linear combination between two or more non-stationary variables is termed as cointegration.

Autoregressive Distributed Lag Model

We applied the bounds test to examine the existence of a long-run equilibrium relationship between electricity generation, manufacturing, services and economic growth. The bounds testing approach of cointegration is involved to establish long run equilibrium relationship between electricity generated and real GDP per capita using autoregressive distributed lag (ARDL) model (Pesaran et al., 2001).

Several cointegration methods are found in empirical literature to determine cointegration between the series but the ARDL bounds testing is superior and preferable due to its various advantages. For instance, order of integration of the series does not matter for applying the ARDL bounds testing if no variable is found to be stationary at I (2). The ARDL cointegration approach has several advantages over other cointegration methods including Engle and Granger (1987), and Johansen and Juselius (1990) procedures: (i) there is no need for equal order of integration of all variables, (ii) it is efficient estimator for even small number of samples with some endogenous regresses (iii) it allows for variables with different optimal lags, and (iv) it employs a single reduced form equation.

Pattichis (1999) stated that the ARDL cointegration test tend to exhibit robust statistical outcomes because it does not push the short run effects into the disturbance terms as the case of Engle and Granger (1987) two-step cointegration approach. In addition, ARDL bounds testing approach has stronger statistical properties in finite sample, Narayan (2005), (Narayan & Smyth, 2005). The bounds testing approach is not affected by the lags structure of the underlying variables, whether purely I (0), purely I (1), or mutually cointegrated (Pesaran et al., 2001).

Yoo and Kim (2010), noted that variables in the electricity-growth model are occasionally mixed in integration orders, mostly I (0) and I (1). Hence, this work employs the autoregressive distributed lag model (Pesaran *et al.*, 2001) to investigate the presence of a long run relationship between electricity generation, services, manufacturing, exports, capital and degree of urbanisation. Lag order selection follows the Akaike Information Criterion for minimizing autocorrelation and heteroscedasticity problems (Mushtag, 2011).

The ARDL method developed by Pesaran et al. (2001) involves establishing the existence of a long-run relationship using the following unrestricted error correction model (UECM):

$$\Delta InY_t = \beta_0 + \beta_1 InEG_{t-1} + \beta_2 ECG_{t-1} + \beta_3 InSG_{t-1} + \beta_4 InMG_{t-1} + \beta_5 \ln EX_{t-1} + \beta_6 \ln CAP_{t-1} + \beta_7 \ln DU_{t-1} + \Sigma_{i=1}^{p} \xi_1 \Delta EG_{t-i} + \Sigma_{i=D}^{q} \xi_2 \Delta InECG_{t-i} + \Sigma_{i=D}^{r} \xi_3 \Delta InSG_{t-i} + \Sigma_{i=D}^{s} \xi_4 \Delta InMG_{t-i} + \Sigma_{i=D}^{t} \xi_5 \Delta InEX_{t-i} + \Sigma_{i=D}^{u} \xi_6 \Delta InCAP_{t-i} + \Sigma_{i=D}^{v} \xi_7 \Delta InDU_{t-i} + \varepsilon_t \qquad (17)$$

Where β_0 is the constant and β_is are the long-run elasticities, ξ_is are the short-run elasticity (where i=1, 2, 3…) and ε_t is the white noise in equation 18. Also Δ and p represents the first difference operator and the lag order selected.

Bounds Testing Approach

Stage 1

We first determine long run relationship among the variables based on an unrestricted ARDL specification using an F-test. The null hypothesis of no cointegration among the variables (H_o: $\alpha = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$) is tested against the alternative hypothesis of cointegration among the variables (H_1: $\alpha \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$). The estimated F-statistic is then compared with the F-statistic based on (1%, 5% and 10%) level of significance of the respective bound critical values provided by Narayan (2004).

Decision rule

The null hypothesis of no cointegration is rejected if the value of the F-statistic is greater than the tabulated upper bound value (evidence long run relationship). However, the null hypothesis cannot be rejected if the value of the F-statistic is lower than the tabulated upper bound value (no evidence of cointegration). If the F-statistic lies between the upper bound I (1) and lower bound I (0), inference remains inconclusive and knowledge of the order of integration of the underlying variables is required before conclusive inference can be made.

Stage 2

We shall estimate the coefficients of the long run relationship by ordinary least square (OLS) once it is certain that there is evidence of cointegration among variables. This would be done after choosing some optimal lags per the least values of the Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC). These criteria are preferable because it helps select a more parsimonious ARDL model.

Granger Causality

Several approaches exist for causality test such as variability determination approach, realization approach and the information approach. The basic aim of this work is to determine the information efficiency of the relationship between electricity generation and economic growth. This approach was adapted because of its simplicity and can be tested empirically (Granger, 1969). Granger (1969), argued that if X causes Y then the history of X can be used to forecast Y more accurately than simply using the history of Y only. It was the first attempt to investigate the presence and direction of causal relationships between variables. A unidirectional causality that runs from the explanatory variables to the dependent variables serve as a prerequisite for the consistent estimation of distributed lag models that do not involve lagged dependent variables (Woodridge, 2011).

The presence of cointegration among the variables was preceded by modelling causal relationship within the dynamic error correction model (Engle & Granger, 1987) and (Granger, 1988). If there is evidence of cointegration then we expect Granger causality in at least one direction (Odhiambo, 2009). Unfortunately, the cointegration analysis does not show the direction of causality between variables in the model (Bildirici & Kayikci, 2012). The granger causality test will be used in this present study to test whether electricity generation stimulates economic growth or economic growth leads to generation of more electricity to power industrial activities, or if there exist feedback effects between electricity generation and economic growth.

The ARDL bounds testing approach is used to test the presence of long run relationship between electricity generation and economic growth. After estimating the long run model to obtain the residuals of the model, we employed the error-correction based on Granger causality model (Shahbaz & Lean 2012).

When cointegration is detected among variables in the underlying model, Granger causality analysis can be augmented with a lagged error correction term and causality is tested using vector correction model (VECM), which has the capacity to capture short run deviations from long term equilibrium path through the error correction mechanism. Below is the mathematical construction of the VECM models:

$$\Delta InY_t = p + \sum_{i=1}^{p} \theta_1 \Delta InEG_{t-i} + \sum_{i=1}^{p} \theta_2 \Delta InECG_{t-i} + \sum_{i=1}^{p} \theta_3 \Delta SG_{t-1} + \sum_{i=1}^{p} \theta_4 \Delta MG_{t-1} + \sum_{i=1}^{p} \theta_5 \Delta EX_{t-1} + \sum_{i=1}^{p} \theta_6 \Delta CAP_{t-1} + \sum_{i=1}^{p} \theta_7 \Delta DU_{t-1} + \gamma ECT_{t-1} + V_t \quad (18)$$

Where ‘p’ is the constant and θ_i are the short-run elasticities, γ is the speed of adjustment parameter and ECT is the Error Correction Term which is the residuals obtained from equation 18. Where Δ denotes the first difference operator, θ_i are parameters representing short run dynamic coefficients of the underlying ECM model, ρ is the optimum lag, ECT is the coefficient of the error correction term and V_t is the white noise error term.

Post Estimation Test

Diagnostic Test

The diagnostic test of the ARDL model from the short-run estimate such as normality, heteroskedasticity and serial correlation test were running to ensure that model can stand the test of time.

Stability Test

We further tested the stability of the model by employing the Cumulative Sum (CUSUM) and the Cumulative Sum of Squares (CUSUMSQ). Stability of the model was tested using cumulative sum charts. Let $X n$ be a discrete random signal with independent and identically distributed samples. Each follows a probability density function p (X_n, Θ) depending on a deterministic parameter Θ. Assuming this signal contains one abrupt change caused by an instantaneous modification of the value of Θ occurring a given time change n_c. Therefore $\Theta = \Theta_0$ before n_c and $\Theta = \Theta_1$ from n_c to the current sample. Under these assumptions, the whole PDF of the signal P_x observed between the first sample X (0) and the current one X(k) can take two different forms.

Data Analysis

We employed quantitative analysis during the study. Charts, graphs and tables are used to offer graphical analyses of descriptive statistics. All data variables are subjected to unit roots test to specify their order of integration. We also adopted auto regressive distributed lagged model Pasaran et al. (2001) bounds testing approach of cointegration to establish both long run and short run equilibrium relationship between electricity generated and real GDP per capita using Pesaran and Shin (1999) and (Pesaran et al., 2001). Empirical estimations were done using Eviews 9.5 package and Microsoft Excel.

Conclusion

This chapter has dealt with the theoretical grounding of the relationship between electricity generation and economic growth. The empirical model was constructed by taking the natural logarithms of the various variables. Taking the natural logs linearized the exponential variation in time series data and leave the variables in their elasticity form. The auto regressive distributed lag model, unrestricted vector correction model and error correction model were used to determine long run and short run relationships. Diagnostic and stability test were conducted as post estimation test to reinforce the robustness and stability of our model.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

This chapter presents the analysis and discussion of results of the study. The main objective of this work is to establish long run relationship and Granger causality between electricity generation and economic growth. We present detail analysis and discussion results of the study under this chapter. We will first examine the results of descriptive statistics of the variables in the first section. The second section of the chapter constitute results of the time series properties of variables tested using Augmented Dickey Fuller and Phillip Peron unit roots test. In the third section, we examine the results and discussion of auto regressive distributed lag bounds testing to cointegration. We then elaborated on both post estimations tests, diagnostic and stability test.

Descriptive Statistics

We carried out descriptive statistics of the various variables using the standard descriptive such as mean, median, maximum, minimum, standard deviation, skewness, kurtosis, sums, sum of squared deviations and number of observations. These statistics are illustrated in Table 1. With close observation, we noticed that all the variables in the table have positive average values (mean and median) except for electricity generation per capita.

The average values are normal except for electricity per capita which of course is a natural log of decimals numbers, the ratio of electricity and total population. Clearly the minimal deviation of the variables from their mean values are shown by the standard deviation. From the results, there is relatively moderate rate of deviations of these variables within our defined period of study. Variables such as real GDP per capita, electricity generation per capita, service value addition, and degree of urbanisation are positively skewed while manufacturing value addition, exports and capital accumulation are negatively skewed.

Table 2: Summary Statistics of the Variables

	LNEG	LNECG	LNMG	LNSG	LNEX	LNCAP	LNDU
Mean	6.921099	-5.837788	20.51709	3.613425	3.232652	2.911464	1.443807
Median	6.869870	-5.876801	20.25131	3.517581	3.377310	3.065833	1.404940
Max	7.436408	-5.037034	21.65608	3.939935	3.887777	3.458987	1.676694
Mini	6.553259	-6.084233	18.86887	3.386537	1.714864	1.321694	1.255699
SD	0.253466	0.197962	0.699175	0.190091	0.507928	0.475491	0.105242
Sk	0.675068	2.129102	0.184008	0.594312	-1.138723	-1.537153	0.332462
Ku	2.435978	9.213791	2.421808	1.671222	4.095688	5.174873	2.269780
JB	2.943856	78.02231	0.645896	4.370406	8.782530	19.49946	1.341098
Prob	0.229483	0.245242	0.724012	0.112455	0.212385	0.112358	0.511428
Sum	228.3963	-192.6470	677.0638	119.2430	106.6775	96.07831	47.64564
SSDev.	2.055837	1.254049	15.64306	1.156305	8.255717	7.234925	0.354426
Obs	33	33	33	33	33	33	33

Max=Maximum, Mini=Minimum, JB=Jarque-Bera,Prob=Probability, SD=Std Dev, Sk=Skewness, Ku=Kurtosis, SSD=SumSq. Dev., Obs=Observation

Note: Std. Dev. Stands for Standard Deviation, Sum Sq. Dev. Represents Sum of Squared Deviation.
Source: Author's Computation using EViews

The Jarque-Bera statistic with null hypothesis that all the series are selected from normally distributed random selection is accepted for electricity generation per capita, manufacturing, exports, capital accumulation and degree of urbanization but rejected for real GDP per capita and services growth.

Discussion of Time Series Properties of the Variables

Results of Unit Root Tests

We tested for unit roots of all the variables, to examine the stationarity properties of all the variables before applying autoregressive distributed lag bound testing to cointegration and Granger causality test. We carried out trend analysis of the graphical representation of the variables (Appendix A). From the curves in Appendix A, we observed all the variables appeared to be non-stationary. But Appendix B, which illustrate the plot of all variable at their first differences exhibit stationarity.

To establish the order of integration, we employed Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test at both level and first difference. The Schwartz-Bayesian Criterion (SBC) and Akaike Information Criterion (AIC) were used to establish optimal number of lags to include in the test. We used the p-values for deciding on unit roots conclusions like critical values. Table 3 and 4 presents the results of both test for unit roots for all the variables at levels with intercept and trend, and their first difference.

Table 3: At Levels with Intercept, Trend and Intercept

	INTERCEPT				TREND AND INTERCEPT			
VARS	ADF	PV	PP	PV	ADF	PV	PP	PV
EG	(-2.363)	0.999	(2.041)	0.999	(0.074)	0.996	(-0.153)	0.991
ECG	(-5.787)***	0.000	(-5.681)***	0.000	(-5.013)***	0.002	(-14.119)***	0.000
SG	(-0.793)	0.807	(-0.763)	0.816	(-1.769)	0.6958	(-1.737)	0.711
MG	(-1.102)	0.703	(-1.134)	0.6897	(-1.784)	0.6888	(-1.899)	0.631
EX	(-3.597)**	0.011	(-3.484)**	0.015	(-3.156)	0.1112	(-3.100)	0.123
CAP	(-4.441)***	0.001	(-5.439)***	0.000	(-4.187)**	0.012	(-4.389)**	0.008
DU	(-0.799)	0.805	(-0.442)	0.8897	(-5.004)***	0.0017	(-4.759)***	0.003

Note: ***, ** and * denotes 1%, 5% and 10% significant levels respectively. Also, VARS, ADF, PP and PV are the Variables, Augmented Dicky-Fuller Statistics, Phillips Peron Statistics and Probability Value Respectively Source: Estimated by Author using Eviews 9.5 Package

As shown in the table, the null hypothesis of unit root for the variables electricity generation per capita (ECG) and capital accumulation (CA) cannot be accepted at both levels and, trend and intercept. Except for real GDP per capita (EG) and service value addition (SG), almost all the variable cannot be accepted of the null hypothesis of unit roots at levels and, trend and intercept. This implies that except for EG and SG all the remaining variables are stationary at level since most of their p-values for Augmented Dickey Fuller and Philip Perron test are significant at some almost all conventional levels of significance.

Table 4: At First Difference with Intercept Trend and Intercept

	Intercept				Trend and Intercept			
VARS	ADF	PV	PP	PV	ADF	PV	PP	PV
EG	(-3.294)**	0.024	(-3.329)**	0.022	(-3.985)**	0.020	(-3.997)**	0.020
ECG	(-4.946)***	0.000	(-6.828)***	0.000	(-5.054)***	0.002	(-7.304)***	0.000
SG	(-5.521)***	0.000	(-5.568)***	0.000	(-5.659)***	0.000	(-6.402)***	0.000
MG	(-4.934)***	0.000	(-4.912)***	0.000	(-4.849)***	0.003	(-4.798)***	0.003
EX	(-4.551)***	0.001	(-4.516)***	0.001	(-4.596)***	0.005	(-4.552)***	0.005
CAP	(-5.964)***	0.000	(-6.927)***	0.000	(-6.5678)***	0.000	(-14.979)***	0.000
DU	(-4.373)***	0.002	(-5.371)***	0.000	(-4.281)**	0.010	(-4.646)***	0.004

Note: ***, ** and * denotes 1%, 5% and 10% significant levels respectively. Also, VARS, ADF, PP and PV are the Variables, Augmented Dicky-Fuller Statistics, Phillips Peron Statistics and Probability Value Respectively Source: Estimated by Author using Eviews 9.5 Package

Clearly, at first difference all the variables are stationary, so we reject the null hypothesis of the existence of unit root within the variables. We do not accept the null hypothesis of the presence of unit roots within D(EG), D(ECG), D(SG), D(MG), D(EX), D(CAP) and D(DU) at 5% for D(EG) and at 1% level of significance for the rest of the variables. It is therefore safe to conclude that all the variables are integrated of order *I* (1). To avoid spurious regression, the first difference of all the variables must be employed in the estimation of the short run equation.

VAR Lag Selection Criteria

The appropriate lag length selection was done before estimating Auto Regressive Distributed Lag (ARDL) models. The lag length plays a vital role in diagnostic tests as well as in estimation of VAR model for cointegration and impulse response (Mushtag, 2011). The appropriate lag length (p) was done using standard model selection criteria (AIC and SBC) to ensure normal distribution white noise errors with no serial correlation. The results of lag selection criteria are presented in Table 4 below.

Table 5: VAR Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	37.744	NA	0.005	-2.460	-2.118	-2.365
1	75.448	51.278	0.000	-5.396	-5.006	-5.288
2	88.857	6.799*	0.000	-5.989	-5.306*	-5.799*
3	76.358	0.638	0.000	-5.309	-4.821	-5.173
4	77.695	1.497	0.000	-5.336	-4.799	-5.187
5	79.194	1.559	0.000	-5.375	-4.790	-5.213
6	81.130	1.859	0.000	-5.450	-4.817	-5.275
7	75.827	0.485	0.000	-5.346	-4.907	-5.224
8	90.020	0.931	0.000	-6.002*	-5.270	-5.799

Source: Computed by Author using Eviews 9.5 Package. *indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level of significance), FPE: Final prediction error, AIC: Akaike Information Criterion, SC: Schwarz Information Criterion, HQ: Hanna-Quin Information Criterion.

It is clear from the VAR lag selection criteria that more asterisks are attached to FPE, SC, and HQ at lag length 1. This is not surprising because of the variables were stationary at levels. The lag length 1 was selected based Schwarz (SC).

Bounds Test for Cointegration

The ARDL bounds test to cointegration was used to determine the presence of cointegration. Below is the representation of the test results.

Table 6: ARDL Bounds Test for Cointegration

Dependent Variable	F(lnEG)=F (lnECG, lnMG, lnSG, lnCAP, lnDU)							
F-statistic	6.6268							
Critical Values	1%		2.50%		5%		10%	
Trend and Intercept	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
K=6	2.88	3.99	2.55	3.28	2.27	3.28	1.99	2.94

Source: Pesaran et al (2001) for F-statistic, Note: *** Statistical significance at 1% level; ** Statistical significance at 5% level, * Statistical significance at 10% level. K is the number of regresses for the dependent variable in ARDL models.

The value of the F- test statistic (6.6268) is used to determine whether a long run relationship exists between the variables through testing the significance of the lagged levels of the variables with following hypotheses.

H_0: $\Theta_1 = \Theta_2 = \Theta_3 = \Theta_4 = \Theta_5 = \Theta_6 = \Theta_7 = 0$

H_1: $\Theta_1 \neq \Theta_2 \neq \Theta_3 \neq \Theta_4 \neq \Theta_5 \neq \Theta_6 \neq \Theta_7 \neq 0$

The computed F-statistics (6.6268) exceeded the respective upper critical bounds values, we then conclude that the variables are cointegrated. If the F-statistics had fell below the respective lower critical bounds, we would have fail to reject the null hypothesis of no cointegration. Small sample size as in our case, the relevant critical values deviated substantially from the critical values reported by (Pesaran et al, 2001).

Clearly, we can conclude based on the empirical findings above that there exist a long run relationship between real GDP per capita, electricity generation, services, manufacturing, exports, capital accumulation and degree of urbanization.

Estimated Long Run Coefficients

We then proceed to examine the marginal impact of electricity generation on economic growth in Ghana. The table below illustrate the long run elasticity of both the dependent and independent variables.

Table 7: Long Run Estimates Results using ARDL

Variable	Coefficient	Std. Error	T-statistic	P-Value
LNECG	0.8109***	0.2208	3.6720	0.0032
LNSG	1.1569***	0.2905	3.9832	0.0018
LNMG	0.0843**	0.1397	0.6031	0.5577
LNEX	0.4870**	0.1718	2.8346	0.0150
LNCA	0.2531**	0.1138	2.2252	0.0460
LNDU	1.8780**	0.8368	2.2442	0.0445
C	0.7637	3.8676	0.1975	0.8468

Note: ***,**, and * denotes statistical significance levels at 1%, 5%, 10% respectively.
Source: Computed by Author

We estimate the long run relationship between the variables in our ARDL model in equation 17 and present the estimated results. The results included the first order autoregressive coefficient of the error term in Table 6, using OLS. Our results reveal that relationships between electricity generation, services and economic growth are positive and statistically significant at 1% level of significance. Exports, capital and degree of urbanisation are also positive and significant at 5%. Furthermore, our results show that the coefficient of manufacturing is insignificant.

Discussion of Long Run Results

The results show that electricity generation, as expected, has a positive significant effect on economic growth. A unit increase in electricity generation will result in about 0.81 increase in economic expansion. The positive sign of the relationship support theoretical argument that economic growth is powered by energy. Yoo and Kim (2006), found causal relationship from economic growth to electricity generation. The results are consistent with Altintas and Kum, (2013) findings, thus, a reduction in electricity generation will affect economic growth negatively. For developing economies to sustain growth there should be steady supply of energy (WDI, 2016). The findings of this study are in tune with works such as Lee et al (2008) and (Stern, 2011). The cross-country studies, including Ghana, found positive relationship between electricity consumption and economic growth (Lee, 2005). However, Wolde-Rufael, (2006) indicated that current energy infrastructure of developing and middle income countries in Africa are still inadequate to support rapid economic expansion that is needed to fight poverty and raise the living standards of people in Africa. A strong positive correlation was found between electricity consumption and economic growth among African countries (Wolde-Rufael, 2006).

Lean and Smyth (2010), found that economic growth resulted in the growth of the commercial and industrial sectors of the Malaysian economy, manufacturing as major consumer of electricity generated. Manufacturing Sector is the key sector and major consumer of electricity in Malaysia (Lean and Smyth, 2010). Mahadevan and Asafou-Adjaye, (2007) in their cross-country study of 20 sub-Saharan African countries found a strong positive relationship between electricity consumption and economic growth in both middle and low income countries including Ghana. It means that as our generation capacity increases, the economy of Ghana will expand as found by electricity consumption studies in Ghana, (Kwakwa 2012), (Adom 2011) and (Eshun and Amoako 2016). The implication of these findings is that, Ghana is an energy dependent economy with services sector contributing more to growth than manufacturing.

Services have become a larger share of GDP in poor countries and productivity growth in services exceeds that in industry for most poor countries (Christen & Francois, 2010). The relationship between economic growth and services value addition is an interesting finding of our study. There is a strong positive long run relationship between economic growth and services. It is found that a unit increase in the services sector will create a growth impact of 1.2 in the Ghanaian economy. Thus, a ten percent increase in service sector of the Ghanaian economy will lead to about 12% increase in economic growth. Communication services are among the fast-growing traded services sectors exhibiting double digit growth worldwide (Eichengree et al, 2011). Services sector has been found to drive the Indian economy (Jain, 2011). Indian's services share of GDP in 1991 was 5 percent above global norm while China showed a negative outlier with 6 percent less in global standard (Jain, 2011). Globalization of service has enabled developing countries to tap into services as a source of growth (Collier & Paul, 2007). Finally, Enu and Okonkow (2015) had similar findings with the results as reported. They concluded there was a strong long term cointegration between services and economic growth.

Jalil, Manan and Saleemi, (2016) found a positive impact of services sector on economic growth in Pakistan. This finding is line with the result of Jensen and Kletzer (2005), Jain (2011) and Singh (2006). Ghani (2011), found that by 2005, India had become a massive service economy compared to the global norm with a size of 6 percent points above global standard. Blinder, (2006) found that growth in the service sector is more correlated with poverty reduction than growth in agriculture for a sample of 50 developing countries. The Ghanaian economy has a huge potential in the service sector. The sector is already in lead in share of GDP than other sectors including manufacturing, contributing 52.2% to gross domestic product (IMF, 2016).

Modern services need a strong telecommunications backbone. Use of the internet, personal computers and telephone lines are all independently significant in service exports (Jensen et al., 2005). Promoting FDI selectively in telecom sectors is now an active component of industrial policy in many developing countries (Alfaro & Charlton, 2007). Globalization of services provides many opportunities for late-developing countries to find niches, beyond manufacturing, where they can be successful. Taking advantage of these opportunities requires a government that energetically takes steps to accelerate services growth, through a variety of policies (Bhagwati, 2004). Services may provide the easiest and fastest route out of poverty for many poor countries.

Sullivan (2002) argued that, in the United States, the service sector has surpassed manufacturing in its contribution to the GNP and in employment. Ramakrishna (2010) investigates the impact the service sector, industry, agriculture and the open policies had on India's economic growth. The study found that service sector appears to contribute more (Ramakrishna, 2010). Per the study, the sources of service sector growth in India appear to be income elasticity of demand, open policies and the growth in the service sectors like communications, business, banking and insurance and trade services (Ramakrishna, 2010).

Enu, Addey and Okonkwo (2015) examined the effects of macroeconomic policies on services output in Ghana using ordinary least squares estimation. GDP per capita was found to affect services output positively and was statistically significant (Enu et al., 2015). Government spending and inflation were found to negatively affect services production in Ghana (Enu et al., 2015). They concluded that macroeconomic policies that enhance favourable economic expansion, ensure effective and efficient government spending and reduce the rate of inflation should be formulated and implement correctly to ensure the continual growth and development of the services sector in Ghana (Enu et al., 2015).

We establish in our study that export and economic growth are strongly related in the long run. However, for Ghana, there was no evidence to support the theoretical claim that manufacturing lead to economic growth. We found that manufacturing was statistically insignificant. Factors that limit the potential of African manufacturing firms in creating export value are their levels of efficiency and size (Soderbom & Teal, 2002). Singh (2005), agreed to this phenomenon and made the case that services sectors such as software, business processing, finance or tourism may act as leading sectors in development and that the role of manufacturing is declining. Adom and Kwakwa (2013), concluded that the coefficient implies that a 1% expansion of the manufacturing sector will increase Ghana's energy intensity by approximately 3%. This phenomenon show that as electricity consumption reduces we expect manufacturing to fall causing a fall in growth.

However, several arguments are raised in literature to show that, countries that have move from low income status to middle income countries did so by investing in industrialization of the manufacturing and construction sectors as major driving forces of their economies (Aryetee, et al., 2005). Osei-Amponsah and Anaman (2008), established Granger Causality from economic growth to manufacturing but however found no Granger Causality running from manufacturing to economic growth. Thus, there was unidirectional causality from economic growth to manufacturing (Osei-Amponsah et al., 2008).

Soderbom and Teal, (2002) in a cross-country study found long run stagnation of manufacturing growth in South Africa, and a long run failure in Zambia but found a higher manufacturing growth in Bostwana and Mauritius. They however found that Ghana, Tanzania and Uganda had a general pattern of contraction in the manufacturing sector. Adom and Kwakwa (2014) argued that activities of the manufacturing sector are highly energy driven, which implies that further expansion in the scale of manufacturing activities in Ghana will spur energy demand pressures. Consequently, energy intensity increases. A changing production mix and technical characteristics of manufacturing sector improved energy efficiency (Adom & Kwakwa, 2014). African countries generally take longer periods to rise in manufacturing growth. Ghana (1975), South Africa (1980), Botswana (1985), Kenya (1985), Egypt (1990), Tanzania (1990), Nigeria (1995), and Uganda (1995) are examples. Sirmai and Vaspergen (2005) found interaction between manufacturing and relative GDP per capita to be negative in a cross country study of selected African countries.

An interesting result has also been noted between exports and economic growth. We found a positive long run relationship between exports and economic growth despite the insignificant relationship manufacturing has on economic growth. Like sources of service sector growth in India, which appear to be income elasticity of demand, open policies and the growth in the service sectors like communications, business, banking and insurance and trade services as argued by Ramakrishna (2010) is not different in Ghana. The Ghanaian economy has been commodity export dependent middle income economy WDI (2016), but banking, communications and insurance sectors are on constant growth. A positive relationship between exports and growth can only be argued to favour commodity dependent claims. We found that a ten percent increase in export value addition will lead to about 5% expansion in the Ghanaian economy.

It is clear services sector of the Ghanaian economy can rake in the needed expansion in economic growth. The "service economy" was found to be dominated by commercial service sector in terms of value addition and employment in the US Song &Witt (2006) and the story is not different for Ghana. Gabriele (2004), showed that the elasticity of GDP growth with respect to export of services and goods was higher in developing countries than developed counties. For developed countries, only in the last decade that growth of services exports of information technology began to show impact on the overall GDP growth (Ramakrishna, 2010). The role of exports as a GDP growth stimulator got significance in the 1980s though less than merchandise trade (Eichengreen et al., 2011).

An increasing degree of urban migration has been a noted phenomenon (Marmara et al., 2015). With a geometric growth in technology, with related employment potential, more people can engage in service provision in one way or the other in densely populated cities. Migration and urbanization are both outcomes of modernization of an economy, linked historically with industrialization, and economic growth (Bhattacharya et al., 1997). We expect service output in urban centres to increase, since new urban residents are expected to rise in the next 20 years, and the urban populations of South Asia and Africa will double (Marmara et al., 2015). The concept of urbanization and economic growth goes in tune; and no country has reached high income status without busy cities that are flooded with innovation, entrepreneurship and culture accounting for 70 percent of global GDP (Outlook, 2016).

The long run effect is specified below as:

$$ECM = + 0.8109LNECG + 0.0843LNMG + 1.1570LNSG + 0.4871LNEX + 0.2532LNCAP + 1.8780LNDU + 0.7637 \quad (19)$$

where EG represent economic growth, ECG is electricity generation per capita, SG is service value addition, MG is manufacturing value addition, EX is exports, CAP capital accumulation and DU is degree of urbanisation. The error correction term of equation is expressed as:

$$ECM = LNEG - (0.8109LNECG + 0.0843LNMG + 1.1570LNSG + 0.4871LNEX + 0.2532LNCAP + 1.8780LNDU + 0.7637) \quad (20)$$

Discussion of Short Run Results

The relationship between cointegrated variables can be computed using an error correction model where an error correction term is incorporated to account for both long run and short run relationships (Engel & Granger, 1987). The error correction term must be significant and negative to show the possibility of a relationship between the short run and long run when there is a shock in the system (Engle et al., 1987). The rate at which convergence to equilibrium will occur is dependent on the size of the error correction term in absolute terms (Engle et al., 1987).

We estimated vector correction model from VAR with a period and error correction term which resulted in an over parameterized model given that some of our variables are non-stationary but cointegrated. Our results in table 7 estimated from the vector correction model shows that all the variables are significant at first difference. The results show that the effect of previous values of real GDP on its current values in the short run is positive and significant at first difference.

Table 8: Results of Error Correction Model (ECM)

Variable	Coefficient	Std. Error	T-Statistic	P-Value
D (LNEG (-1))	0.2429***	0.0735	3.3069	0.0063
D(LNECG)	0.0525***	0.0146	3.6039	0.0036
D (LNECG (-1))	-0.1227***	0.0188	-6.5124	0.0000
D(LNSG)	-0.0177	0.0288	0.6158	0.5495
D(LNMG)	0.0887***	0.0106	8.3505	0.0000
D (LNMG (-1))	-0.0605***	0.0096	-6.2847	0.0000
D(LNEX)	0.1195***	0.0149	8.0122	0.0000
D (LNEX (-1))	-0.0750***	0.0120	-6.2456	0.0000
D(LNCAP)	0.0231**	0.0099	2.3369	0.0376
D(LNDU)	-0.0578	0.0642	-0.8998	0.3859
D (LNDU (-1))	-0.3111***	0.0622	-5.0033	0.0003
ECM	-0.2236 ***	0.0244	-9.1613	0.0000

R-squared = 0.999224, Adjusted R-Squared = 0.998210, DW = 2.572492, F-Statistic = 984.9520, Prob = 0.0000 Source: Computed Using Eviews.

It is clear from the results that the estimated coefficient of the error correction term (ECT) is negative and significant. An efficient way of estimating cointegration is through the error correction term (Narayan, 2005). Our computed coefficient of the error correction term is -0.2236. This means the speed of adjustment of our model is approximately 22 percent annually. The negative and significance of the coefficients is an indication of the existence of cointegration relationship among the variables.

Narayan (2005) argued that the larger the absolute value of the error correction term, the faster the speed of adjustment during a shock. The size of our coefficient is about half the speed of adjustment which is moderate and may not create undue pressure in the economy.

Electricity generation is significant in the short run and shows positive effect on growth in the short run. Thus, a one percent increase in electricity generation will lead to about 0.055 immediate effect on the real GPD Per Capita.

At the first difference electricity generation is significant at1% with coefficient of -0.1227. The net effect of electricity generation on economic growth in the short run is -0.0702. This results is consist with the findings of Soytas and Sari (2003), who argued that greater energy consumption leads to decreased GDP in France in the short run.

Surprisingly, manufacturing was significant and positive in the short run with a coefficient of 0.0887. And significant but negative at first difference with a coefficient of -0.0605 resulting in a net effect of 0.0282. For a unit increase in manufacturing in the short run we expect real GDP per capita to grow by 0.0282. The major challenge of local industries is the volatility of the local currency, while most manufacturing inputs are imported, an unstable currency affects the value of locally manufactured goods in the long run. It is reasonable for manufacturing to therefore affect growth positively in the short run but no effect in the long run.

Our study examined exports and economic growth and found that, there is a significant positive effect between the two variables in the short run and a negative effect at first difference of the variables in the short run. A unit increase in export in the short run will lead to a positive coefficient of 0.1195 and a negative significant coefficient of -0.0750. The net effect is 0.0445 expansion in growth in the short run is explained by a unit increase in exports in the short run. This phenomenon conforms to theory. Growth in export leads to economic growth in the short run based on our findings.

There is a significant positive relationship between capital and economic growth. In the short run, a unit increase in capital will lead to 0.0231 growth of the economy. An increase in amount of production factors will naturally induce increase in production, Bowden (2010), a deduction that is supported by theory. The positive sign of the variable is a confirmation of the argument that capital supports economic growth in both short and long run.

Degree of urban migration is significant and negative in the short run with positive coefficient even at lag one. From our results a unit increase in urban migration rate affects economic growth by -0.0578 at lag one in the short run but positive in the long run.

Granger Causality

To determine the direction of causality between primary and secondary sectors of the economy and economic growth, we conducted a Pairwise Granger causality test using lag 1. The findings are represented in the table below.

Table 9: Results of Granger Causality between Variables of the Model

Null Hypothesis:	Obs	F-Statistic	P-Values
LNECG does not Granger Cause LNEG	32	(7.9024)***	0.0088
LNEG does not Granger Cause LNECG		(4.1451)**	0.0510
LNMG does not Granger Cause LNECG	32	(1.2381)	0.2750
LNECG does not Granger Cause LNMG		(7.5106)**	0.0104
LNSG does not Granger Cause LNEG	32	(3.6226)*	0.0670
LNEG does not Granger Cause LNSG		(3.6816)*	0.0649

Note: *, ** and *** represent rejection of the null hypothesis at 10%, 5%, and 1% level of significance
Source: Computed by Author using Eviews 9.5 package.

The Granger causality test between economic growth and electricity generation as illustrated in table 9 shows a bidirectional causality between the two variables. Granger causality running from electricity generation to economic growth is very strong and significant at 1%. The Granger causality running from economic growth to electricity generation is also significant at 5%. This shows the stronger dependence of the Ghanaian economy on electricity generation. This support existing literature that both industry and services sector, which are the major drivers of growth, are energy dependent (CEPA 2007). Altintas and Kum (2013) found a bidirectional Granger causality running from economic growth to electricity generation and concluded the finding supports feedback hypotheses for Turkey. Yoo and Kim, (2006) found a bidirectional relationship from economic growth to electricity generation. Our results also confirm the feedback hypotheses for electricity generation and economic growth in Ghana. Lean and Smith (2010), in their studies found a unidirectional Granger causality running from economic growth to electricity generation in Malaysia which is in contrast with our findings. Adom et al. (2012), also found that there exists a unidirectional causality running from economic growth to electricity consumption in Ghana.

There is a bidirectional causality running from services sector to economic growth with both at 10% level of significance. Thus, an increase growth in the services sector will lead to expansion in the economy. Also, expansion in the economy will lead to more services growth to create more jobs. The feedback hypothesis between services and economic growth is confirmed with our results. Jalil et al. (2016), found that services sector granger caused economic growth in Pakistan. This is particularly frightening because services-led growth is a demand-driven growth and always remain shaky however, Oulton (2001) argued that business related service has a continual lead towards economic growth of an economy, while the household services are the burden on an economy.

Our results show a neutral Granger causality running from economic growth to manufacturing. Economic growth is found not to Granger cause manufacturing sector of the economy, just manufacturing does not Granger cause economic growth. This is like what the findings of Osei-Ampomsah et al., (2008) of no causality between manufacturing and economic growth.

Our findings show a unidirectional Granger causality running from electricity generation to manufacturing. There was no evidence of manufacturing growth giving rise to generation of electricity. That is an increase in generation of electricity will lead cause growth in the manufacturing sector. But Adom and Kwakwa (2014), found contrasting result of 1% expansion of the manufacturing sector to increase Ghana's energy intensity by approximately 3. Thus, expansion in the generation of electricity can drive the manufacturing sector of the Ghanaian economy. The results are not also consistent with the results of Lean and Smith (2010), who found in Malaysia, it is rather growth in manufacturing that is generating demand for electricity.

Model Evaluation Test

To ensure our model is robust and truly communicates the findings, we undertake an evaluation of the model with various test available. We perform residual diagnostics and model diagnostics as post estimation tests.

Table 10: Goodness of Fit Tests

	Goodness of Fit		
R-squared	0.9989	F-Statistic	1305.45
Adjusted R-squared	0.9982	Prob. (F-Statistic)	0.0000
Durbin-Watson Stat	2.0767	Schwarz Criterion	-5.3667

Source: Computed By Author

The residual square of our model is 0.9989. The implication is that about hundred percent of a disequilibrium in the product market of the Ghanaian economy is dependent on the variables captured in our model. It also means that our model explains all the variability of the response data around its mean. The higher the R-squared, the better the model fits your data. But R-squared does not indicate if a model is adequate or if the coefficient estimates and predictions are biased.

Our Durbin-Watson (DW) statistic is 2.076 which is about 2. The DW measures the linear association between adjacent residuals from a regression model. If there is no serial correlation, the DW statistic is around the value 2. The DW statistic will fall below 2 if there is positive serial correlation. If there is negative correlation, the statistic will lie between 2 and 4. We therefore conclude that our model has no serial correlation.

The Schwarz Criterion in our model is -5.3667. Schwarz Criterion is an index used as an aid to choose between competing models. The indexes consider both statistical goodness of fit and the number of parameters that must estimate to achieve this goodness of fit, by imposing a penalty for increasing the number of parameters (Schwarz, 1978). The lower the value of Schwarz Criterion the better the fit.

Table 11: Model Residual Diagnostics

Model Diagnostics			
Test Statistic	Test	F-Statistic	Prob.
Serial Correlation	X^2_{Auto}	F (2,10)0.434651	0.6592
Functional Test	X^2_{Reset}	F (2,10)9.132587	0.505
Normality test	X^2_{Norm}	Normal Distribution	0.565
Heteroskedasticity	X^2_{white}	(18,12)0.405027	0.9595

Source: Computed by Author

Model Stability Test

Cumulative Sum and Cumulative Sum of Squares Test

This test is based on cumulative sum of the recursive residuals (Brown, 1975). After the estimation of models Pesaran and Pesaran (1997), argued that the cumulative sum of recursive residual (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) tests can be used to assess the parameter repetitiveness. The output is a graph of CUSUM statistic and bands representative of the bounds of the critical region for a test at the 5% significance level. If the cumulative sum and cumulative sum of square goes outside the area between two critical bounds, then we conclude that the model is unstable. From appendix D, figure 7 and 8, represent plotted CUSUM and line and CUSUMSQ respectively can be found within the 5 percent critical lines, indicating no systematic changes in the regression.

Conclusion

In this chapter, we presented descriptive statistics of the study. We also examined the time series properties of the data used for study. The results of the study are also presented and discussed under this chapter. To achieve stationarity, we employed units' roots test by using both Augmented Dickey Fuller and the Phillip Peron techniques. The results show that all the series have different integration levels. The implication is that we have both I (0) and I (1) in the series. The presence of non-stationary variables means we expect the possibility of long run relationship between the variables. We verified that by using Auto Regressive Distributed Lag Model of cointegration test. Granger causality test indicates a bidirectional causality between electricity generation and economic growth but there was neutral Granger causality running from manufacturing and economic growth. Our findings verify the neutrality hypothesis for manufacturing and economic growth.

A unidirectional causality running from electricity generation and manufacturing was found for Ghana. The results also established a bidirectional granger causality between services and economic growth. Our vector correction model showed a negative error correction term for economic growth with 22% speed of recovery from a disequilibrium from previous year's shock. Our model has been shown to be stable.

CHAPTER FIVE

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

Introduction

Our final chapter presents summary, conclusion and recommendations. The summary presents a brief overview of the research problem, objective, methodology and findings. The conclusions show the overall findings of the study based on the hypotheses. Recommendations are made to offer policy prescriptions, implementable by specific bodies. Last part of this chapter acknowledges the limitations of our study and suggests directions for research.

Summary

The main objective of the study was to examine the relationship between electricity generation and economic growth in Ghana. We employed annual time series data from 1983 to 2015. The study examines long run effects as well as causal relationships between electricity generation and economic growth in Ghana using Auto Regressive Distributed Lag model and Granger causality methods.

We specified an empirical model based on review of literature on the electricity and economic growth findings. The independent variables constituted in the model are electricity generation, manufacturing, services, exports, capital and urbanisation while gross domestic product is the dependent variable. To determine the long run effects of electricity generation on economic growth, Auto Regressive Distributed Lag Model of cointegration was used based on its advantages over other techniques.

As part of the procedure, time series properties of the variables were analysed by the using standard test of stationarity. We employed Augmented-Dickey Fuller (ADF) and Phillips-Peron test techniques. The Auto Regressive Distributed Lag Model of cointegration and Vector Error Correction Model results showed long run and short run relationships between electricity generation, manufacturing, services, exports, capital and urbanisation and economic growth.

The long run results for our regression shows that, there is a significant positive effect between electricity generation and economic growth. This implies that Ghanaian economy is energy dependent economy. We found positive insignificant long run cointegration between manufacturing and economic growth despite positive and significant cointegration between electricity generation and economic growth. This phenomenon is attributable to the foreign exchange volatility regimes we experience in Ghana. Most manufacturing inputs are imported and thus depreciation of the cedi against major trading currencies affects manufacturing overhead cost in the long run. Most factories in Ghana has being laying off workers since 2012.

In the short run, the effect of services on economic growth is negative and insignificant but a strong positive long run cointegration exist between services and economic growth. Major drivers of the services sector in Ghana are the financial and insurance services whose contribution to growth might not be felt in short run, but the strong positive long run relationship between services and economic growth confirms the effectiveness of the service industry the Ghanaian economy. With current contribution of 52.2% to the country's gross domestic product, it is safe to say Ghana is a service-led economy.

We found positive and significant relationship between exports and economic growth in both short run and long run. This is true for a commodity export dependent economy like Ghana. Most of our exports comes from agriculture and exploration of precious minerals which are exported in their raw form. With a recent oil found in Ghana export share of total growth can only go up.

In the short run, there is a positive and significant relationship between capital and economic growth. Also, the long run relationship between capital and economic growth is positive and significant. Capital is the means of financing of the economy.

The short relationship between urbanisation and economic growth is found to be negative and significant. But there is a positive and significant long run relationship between urbanisation and economic growth. Per capita national income is a force that drives labour transfer from agrarian sector to industry and other non-agricultural sectors and with further expansion of the economy, labour will transfer to services sector.

Conclusions

Our study examined the impact of electricity generation on economic growth. We finds a long run cointegration between electricity generation and economic growth in Ghana. We conclude that Ghana is an energy dependent economy.

The study finds a bidirectional Granger causality between electricity generation and economic growth. This shows a feedback energy hypothesis of electricity generation and economic growth is true for Ghana. More investment in the electricity sector will boost economic growth which will lead to more investment in the energy sector for further growth.

Recommendation

Economic growth is found to be influence in the long by continues supply of electricity. Ministry of energy should push for policies that will ensure uninterrupted supply of electricity to power industrial production to boost economic growth in the long run.

The feedback hypothesis of electricity generation and economic growth only means a thriving economy will lead to more demand for electricity. The ministry of finance and economic planning should establish investment policies to encourage local participation in the services industry and manufacturing to grow the economy, since growth of the economy has the potential of causing more investment in the generation of more electricity generation.

Limitations of the Study

We adapted the Autoregressive Distributed Lag (ARDL) model of cointegration. A major limitation of the method is that it is less appropriate for a system of equations and sensitive to both model specification and lag selection. A selected lag length affects the outcome of the cointegration and causality (Pesaran et al., 2001). But the cointegration and causality test produced consistent results.

In running analysis, of this nature, we needed much more comprehensive and longer span annual time series data to produce highly reliable estimates of cointegration analysis. But in a developing country like Ghana, poor quality amid limited availability of annual data are major limitations faced in the study. However, the use of limited amount of data with a total sample size of 32 observation does not risk the validity of our findings since ARDL bounds testing of cointegration proves efficient for data between 30 to 80 observations (Smyth et al., 2010).

Direction for Future Studies

Future study can attempt to desegregate the generation mix of electricity in Ghana to ascertain policy direction for the most cost efficient options of generation in Ghana. An attempt to focus on causality studies on services and growth will enrich the growth literature of Ghana.

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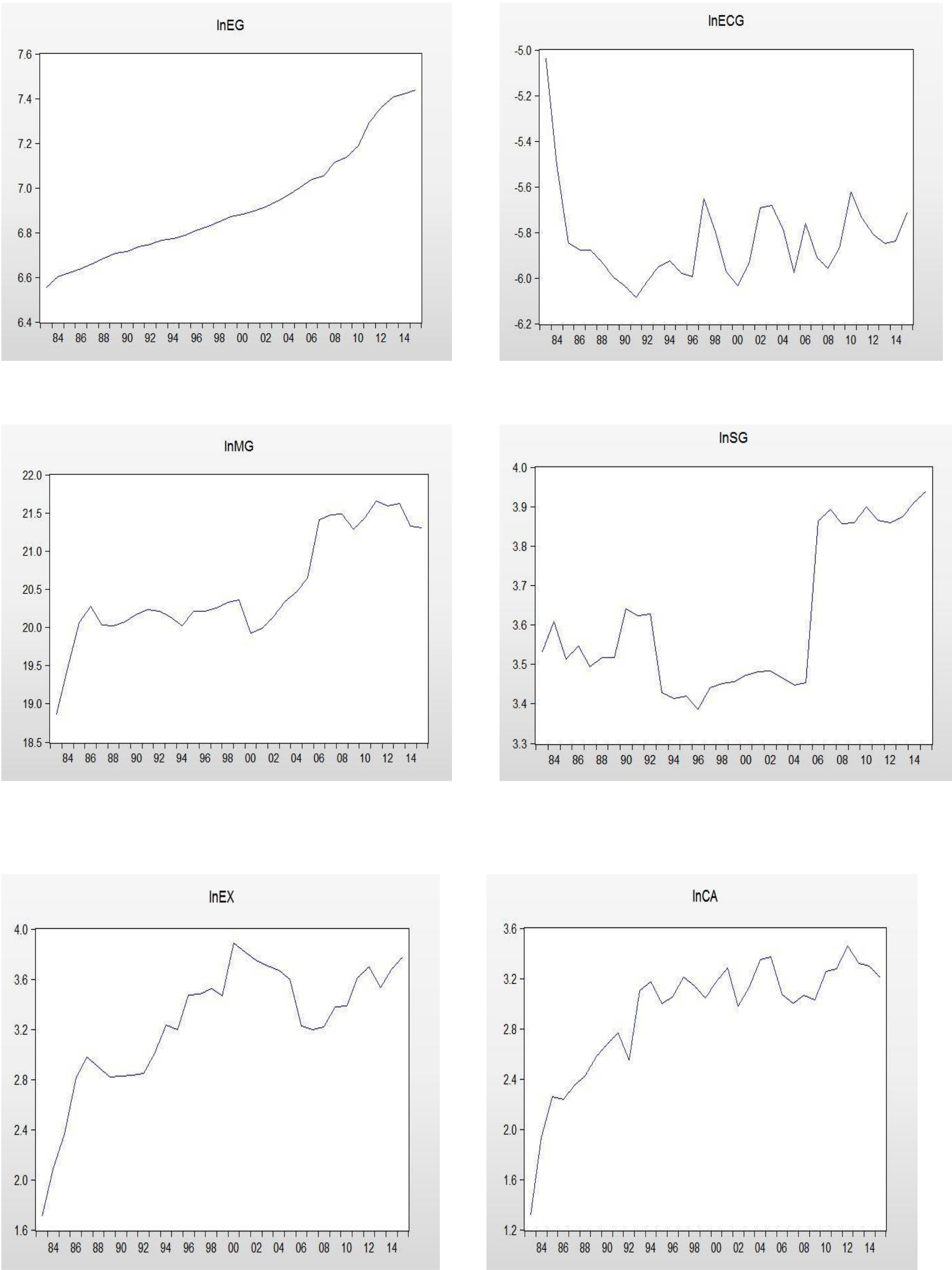
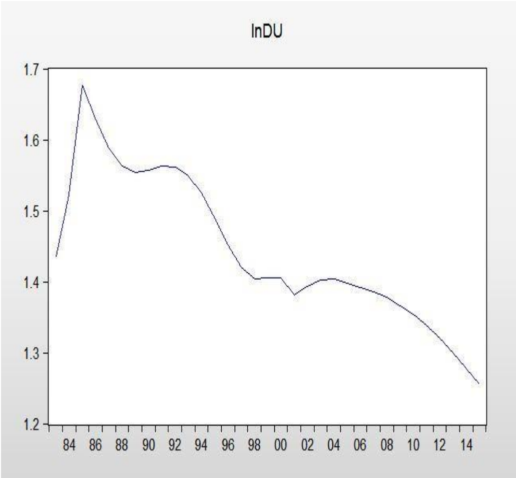
APPENDICES

APPENDIX A

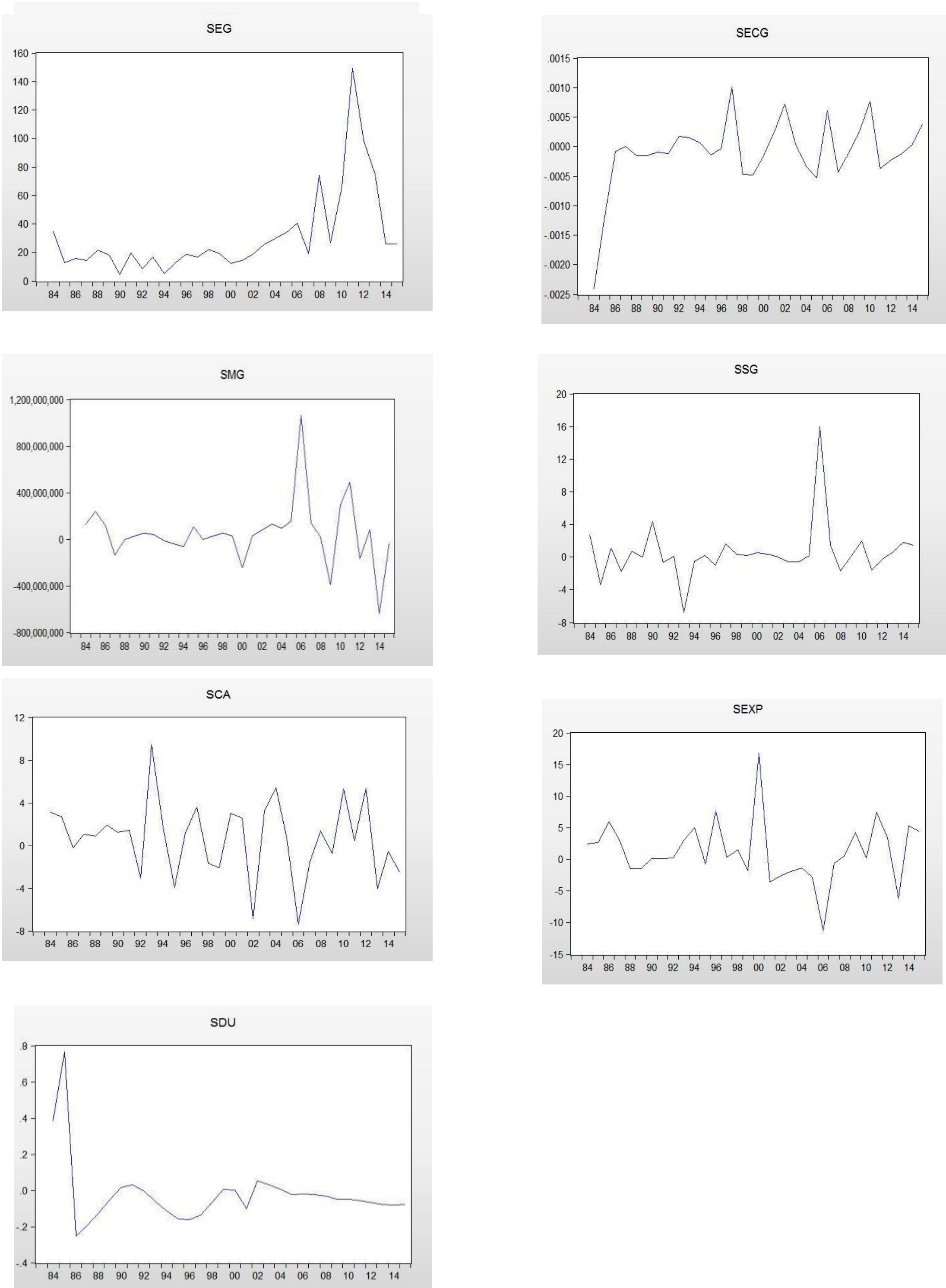
Figure 3: Plots of Variables at level




lnDU
1.7
1.6
1.5
1.4
1.3
1.2
84 86 88 90 92 94 96 98 00 02 04 06 08 10 12 14

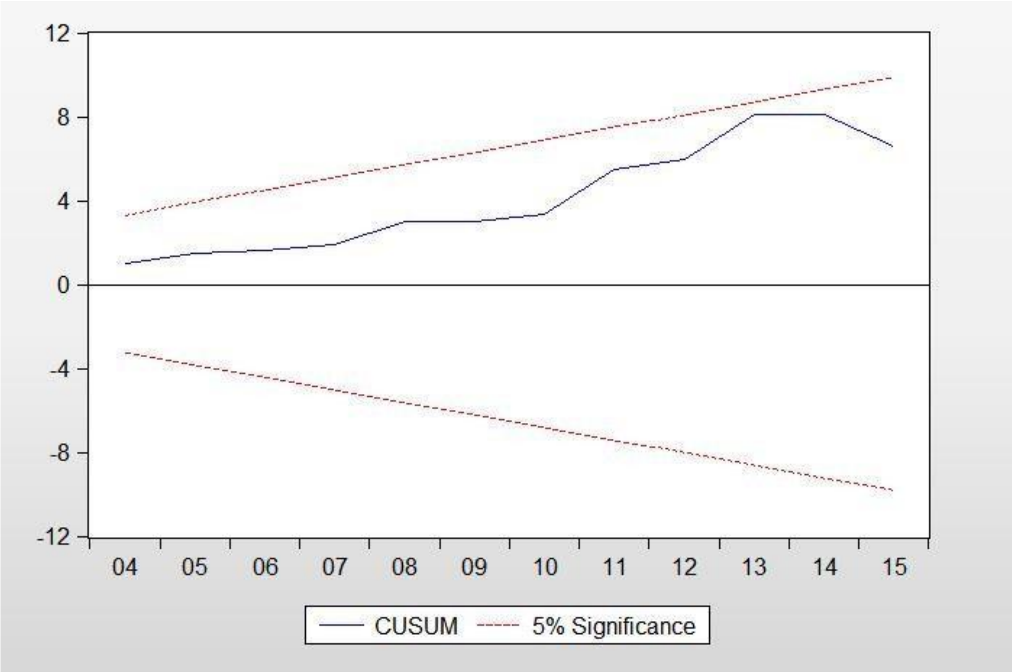
APPENDIX B

Figure 4: Plots of Variables at First Difference

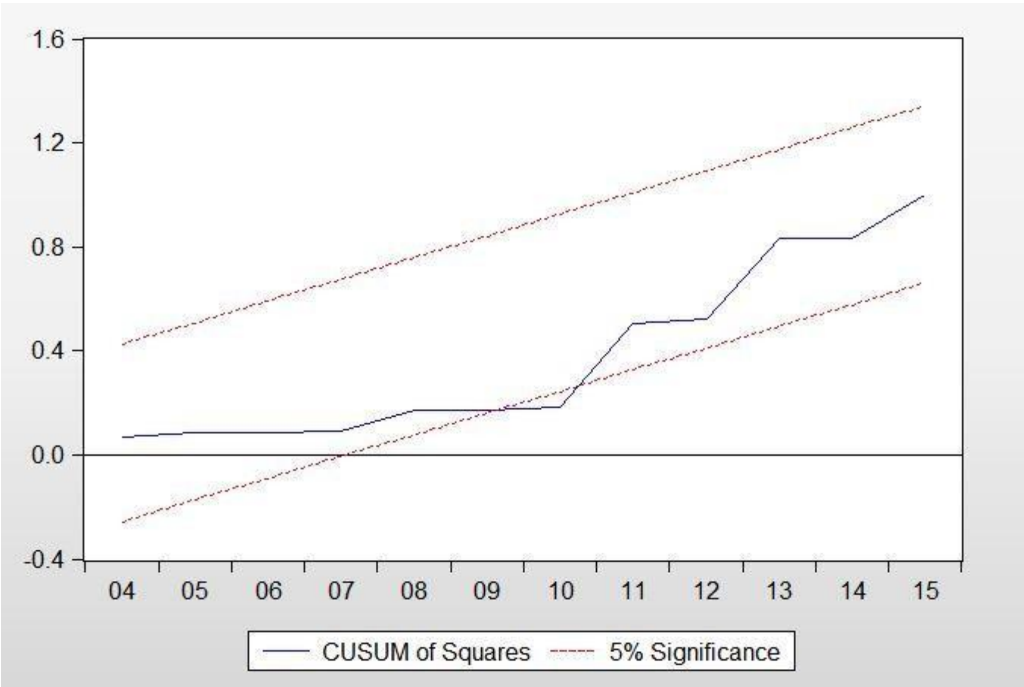


APPENDIX C

Figure 5: Cumulative sum



Cumulative sum square



YEAR	EG	lnEG	ECG	lnECG	SG	lnSG	MG	lnMG	EX	lnEX	CA	lnCA	DU	lnDU	POPULATION	ELECT GEN
1983	701.526525	6.553259	0.006493	-5.037034	34.175108	3.531498	156547617	18.868871	5.555918	1.714864	3.749769	1.321694	4.200227	1.435139	11895130	1832000000
1984	736.434485	6.601820	0.004079	-5.501843	36.942472	3.609362	282224398	19.458213	8.044027	2.084930	6.876823	1.928157	4.583729	1.522513	12311166	3018000000
1985	749.277570	6.619110	0.002889	-5.846935	33.576955	3.513840	519463120	20.068306	10.654486	2.365981	9.570089	2.258643	5.347846	1.676694	12716238	4402000000
1986	764.910458	6.639759	0.002802	-5.877283	34.729534	3.547590	638624117	20.274827	16.576097	2.807962	9.362076	2.236667	5.094283	1.628119	13103975	4676000000
1987	779.204821	6.658274	0.002804	-5.876801	32.943890	3.494806	501496599	20.033107	19.662601	2.978718	10.434048	2.345074	4.900287	1.589294	13480381	4808000000
1988	800.944361	6.685791	0.002648	-5.933885	33.682302	3.516973	497089937	20.024282	18.183383	2.900508	11.295990	2.424448	4.775844	1.563571	13852597	5231000000
1989	819.213130	6.708344	0.002488	-5.996371	33.702804	3.517581	525523280	20.079905	16.742637	2.817959	13.209014	2.580899	4.727526	1.553402	14232493	5721000000
1990	823.581673	6.713663	0.002395	-6.034563	38.077366	3.639620	574951477	20.169796	16.877890	2.826005	14.443997	2.670279	4.743943	1.556869	14628260	6109000000
1991	843.190919	6.737193	0.002279	-6.084233	37.457906	3.623218	611625000	20.231630	16.963546	2.831067	15.878986	2.764997	4.774746	1.563341	15042736	6602000000
1992	851.626345	6.747148	0.002451	-6.011365	37.589513	3.626725	598485126	20.209912	17.225955	2.846417	12.800000	2.549445	4.768714	1.562077	15471527	6313000000
1993	868.471881	6.766735	0.002603	-5.950907	30.833984	3.428617	559784284	20.143062	20.253919	3.008348	22.210170	3.100550	4.708172	1.549300	15907244	6110000000
1994	873.406477	6.772401	0.002672	-5.925088	30.364079	3.413260	495815900	20.021715	25.258636	3.229168	23.957733	3.176291	4.592191	1.524357	16339344	6116000000
1995	886.449233	6.787224	0.002529	-5.979853	30.554174	3.419501	603002502	20.217432	24.496446	3.198528	20.021415	2.996802	4.433962	1.489293	16760991	6627000000
1996	905.201053	6.808157	0.002493	-5.994128	29.563403	3.386537	598776758	20.210399	32.112182	3.469235	21.199996	3.054001	4.272259	1.452143	17169214	6886000000
1997	921.746011	6.826270	0.003505	-5.653678	31.216243	3.440939	623779297	20.251307	32.410291	3.478476	24.806213	3.211094	4.135952	1.419718	17568583	5013000000
1998	943.565929	6.849666	0.003033	-5.798288	31.540533	3.451273	672361592	20.326307	33.871352	3.522570	23.109389	3.140239	4.071148	1.403925	17969006	5925000000
1999	962.823574	6.869870	0.002545	-5.973522	31.710557	3.456650	696624156	20.361757	32.078339	3.468181	21.000535	3.044548	4.075282	1.404940	18384426	7223000000
2000	975.081014	6.882521	0.002395	-6.034229	32.198988	3.471935	449311800	19.923228	48.802258	3.887777	23.998600	3.177996	4.078619	1.405758	18824994	7859000000
2001	989.443555	6.897143	0.002651	-5.932827	32.537363	3.482389	478500628	19.986168	45.233016	3.811827	26.599422	3.280889	3.978015	1.380783	19293804	7278000000
2002	1008.136412	6.915859	0.003371	-5.692525	32.591155	3.484041	556650681	20.137448	42.616252	3.752236	19.700000	2.980619	4.029951	1.393754	19788181	5870000000
2003	1033.545145	6.940750	0.003408	-5.681603	32.004068	3.465863	685048454	20.345000	40.679043	3.705713	22.936928	3.132748	4.062248	1.401736	20305396	5958000000
2004	1063.400462	6.969227	0.003070	-5.786014	31.394731	3.446640	776409116	20.470190	39.303325	3.671309	28.377507	3.345597	4.067967	1.403143	20840493	6788000000
2005	1097.235607	7.000549	0.002538	-5.976533	31.603079	3.453255	928864614	20.649474	36.449217	3.595920	29.002141	3.367370	4.043819	1.397190	21389514	8429000000
2006	1137.549077	7.036631	0.003146	-5.761664	47.599413	3.862820	1989616258	21.411208	25.192626	3.226551	21.635665	3.074343	4.022403	1.391880	21951891	6978000000
2007	1156.639093	7.053274	0.002707	-5.912017	49.025442	3.892339	2128368370	21.478621	24.525091	3.199697	20.107765	3.001106	3.999883	1.386265	22528041	8323000000
2008	1230.362459	7.115064	0.002587	-5.957210	47.347109	3.857506	2152102373	21.489711	25.029457	3.220053	21.452315	3.065833	3.967648	1.378173	23115919	8935000000
2009	1257.493030	7.136875	0.002835	-5.865781	47.436784	3.859398	1759243399	21.288150	29.291866	3.377310	20.670655	3.028715	3.919362	1.365929	23713164	8365000000
2010	1323.099141	7.187732	0.003607	-5.624906	49.364663	3.899235	2055536408	21.443803	29.476718	3.383601	25.995907	3.257939	3.871499	1.353642	24317734	6742000000
2011	1471.971358	7.294358	0.003229	-5.735687	47.734990	3.865665	2541645985	21.656078	36.936609	3.609203	26.440088	3.274881	3.814516	1.338814	24928503	7721000000
2012	1569.955905	7.358803	0.002999	-5.809630	47.461596	3.859921	2374034636	21.587857	40.359218	3.697820	31.784754	3.458987	3.746107	1.320717	25544565	8519000000
2013	1644.845340	7.405402	0.002880	-5.849869	48.111930	3.873530	2456593828	21.622042	34.189079	3.531906	27.732138	3.322592	3.668592	1.299808	26164432	9084000000
2014	1670.679452	7.420986	0.002912	-5.838840	49.927599	3.910574	1819971483	21.322087	39.523559	3.676897	27.139378	3.300986	3.588229	1.277659	26786598	9198000000
2015	1696.644595	7.436408	0.003306	-5.711901	51.415270	3.939935	1783694564	21.301953	43.850406	3.780784	24.627962	3.203882	3.510292	1.255699	27409893	8290000000