UNIVERSITY OF CAPE COAST

FINANCIAL IMPLICATION OF ELECTRICITY USE AND DISTRIBUTIONAL LOSSES ON INDUSTRIAL AND ECONOMIC PERFORMANCE IN GHANA

BENJAMIN KORANTENG OKYERE

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BY

BENJAMIN KORANTENG OKYERE

Dissertation submitted to the Department of Finance of the School of Business, College of Humanities and Legal Studies, University of Cape Coast in partial fulfillment of the requirements for the award of Master of Business Administration degree in Finance

AUGUST 2021

DECLARATION

Student's Declaration

I hereby declare that this dissertation 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.

Student's Signature:.................................... Date.......................................

Name: Benjamin Koranteng Okyere

Supervisor's Declaration

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

Supervisor's Signature:.................................. Date.................................

Name: Prof. Anokye Mohammed Adam

ABSTRACT

The purpose of the study was to examine the relationship among electricity consumption, distributional losses, service value added and GDP per capita growth rate in Ghana. The analysis of the study consider the effects of electricity from both industrial and national level using service value added and GDP per capita growth rate. The study used time series for the period of 1984 to 2018 on the economy of Ghana. The study used time series for the period of 1988 to 2018 on the economy of Ghana. The quantitative research approach was followed for the analysis which allows for series of hypothesis on the relationship among the variables to be tested. The Auto-Regressive Distributed Lag (ARDL) model was followed to test the various electricity consumption-economic growth hypotheses as explained in the literature review. The results indicated a negative simultaneous relationship between per capita electricity consumption and GDP per capita growth rate in Ghana. That is, electricity consumption and GDP per capital growth rate explain each other in the Ghanaian context. The results observed an expected negative relationship between electricity distributional losses and GDP per capita growth rate. That is, reducing distribution losses could increase GDP per capita income of Ghana. The Distribution companies must invest into modern technologies to reduce distributional loses since the overall effects of reducing distributional loses shall be positive on both industries and economic performance. The metering department of the distribution companies must ensure proper metering regulation and reduce the number of companies that are located in house who are using residential rate for commercial purposes.

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To my late parents, Mr. Okyere Budu and Mrs. Veronica Abena Attaa of blessed memory, your desire for me to attain higher education has this day materialized though you did not live long to witness it. Thank you, my great siblings; Thomas Osei Koranteng, Gladys Korantemaa, George Koranteng, Mercy Okyere, Mary Okyere and Emmanuel Budu for the support, encouragement and sacrifices.

DEDICATION

To my parents and siblings

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ADRL	:	Auto Regressive Distributed Lag
EC	:	Electricity Consumption
ECG	:	Electricity Corporation of Ghana
EX	:	Exports
FDI	:	Foreign Direct Investment
GDP	:	Gross Domestic Product
GWh	:	Giga Watts Hour
SME's	:	Small and Medium Enterprises.
SURE	:	Seemingly Unrelated Regression Equation
T &D	:	Transmission and Distribution losses
US	:	United State
VRA	:	Volta River Authority
WDI	:	World Development Indicators
FPE	:	Final Prediction Error

CHAPTER ONE

INTRODUCTION

This section provides a brief overview to the work by providing information on what was studied and why it was studied. It provides the general and specific aims of the study, the stated hypothesis and the rationale for conducting the study. The delimitation and limitations of the study were provided along with definition and organization of the study. It was designed to set the reader into perspective on what to expect from the research report.

Background to the Study

Electricity crisis has become a recurrent development challenge that impend the economic transformation and growth of most emerging economies including Ghana (Eshun, 2016). Electricity consumption fluctuates at the household and industrial levels during periods of erratic power supply. The effects of such erratic supply on the household is obvious since less efficient alternative to energy exist such as the use of petroleum products, liquefied gas and charcoal in the special case of Ghana. The situation seems more compelling at the industrial level where the demand for alternative sources of electricity such as generators appears to be a must in order to avoid stock-out and its associated losses (Beteryeb, 2017).

The actual effects of fluctuations in electricity supply and consumption, however, depends on the electricity intensity of a given industry as well as the existence of less electricity dependent option (Abokyi, Appiah-Konadu, Sikayena & Oteng-Abayie, 2018). It is at this point that the role of electricity consumption and its associated supply problem differ from one sector to another. The manufacturing sector is noted for being more electricity intensive in production than the service sector (U.S. Energy Information Administration, 2016) which suggests electricity consumption may impact differently on the performance of manufacturing firms as compared to the service sector. That is, if it costs less to use electricity and its productivity gain exceed its cost of operations; then electricity consumption shall boost production in the manufacturing than the service sector (Velasco-Fernándeza, Giampietroab & Bukken, 2018).

If, however, the cost of electricity outweighs its productivity gains, then the manufacturing sector shall benefit less from electricity consumption than the service sector. In order words, since the service sector may use electricity only in its productive point, the firms in the service industry shall benefits more from electricity consumption. The bottom line from the discourse is the fact that the electricity consumption effects on performance may be sector dependent, which requires disaggregated analysis of each sector.

Electricity is clearly not the only source of energy to firms and households in Ghana but occupies an important place in the energy use of the country. According to Eshun (2016), Ghana produces around 64 % of its electricity from hydro sources. Electricity is the main source of modern energy used in Ghana, representing about about 35 % in residential use and about 65 % of the energy used in the service and industrial sectors (Eshun, 2016). Despite its role in the energy needs of manufacturing and service sector, the electricity subsector of Ghana is bedeviled with several challenges.

Mensah, Kemausuor and Brew-Hammond (2014) identified low revenue collection, inefficiency in metering and high transmission and distribution (T & D) losses resulting from power theft, as the major setback to power supply in the power sector of Ghana. Ghana's transmission and distribution losses exceed that the rest of the world average, with the highest average value of 27% in the past four decades (Amoako & Asamoah, 2015). The demand side bottleneck has been blamed mainly on high tariffs and utility process of energy products such as electricity. The demand and supply factors are clearly indistinguishable since the supply bottlenecks usually translates to high utility prices which can have its own performance effects for firms and the nation at large.

The perennial nature of power outages has engrossed the attention of a number of studies that have devoted attention to the effects of continuous power outages and its accompanying load shedding on the performance of enterprises both within and outside Ghana. The results have been consistent on negative effects of power outages on performance of enterprises. But the question still remains as to whether a stable power supply actually increases electricity consumption and hence improves performance of firm at the industry level (Lee, Lotsu, Islam, Yoshida & Kaneko, 2019). That is, during power outages, the item of interest in the supply process is access, while during stable supply period affordability still remains a challenge (Lee et al., 2019).

Peters, Sievert and Vance (2013) combine manufacturing and service microenterprises in the then Brong-Ahafo region in Ghana to examine the effect of electricity usage on the financial performance of enterprises. They used a cross-sectional firm-level data from the manufacturing and service sectors to examine the effects of getting connected to the national electricity grid on profits of enterprises. The analysis observed no statistical significant effect of being connected to the national grid on the profitability of the micro-enterprises, with the outcome being robust over different methods like instrumented variables approach and Ordinary Least Squares method. A recent study by Odotei (2016), however, observed that electricity supply has a significant positive effect on both profitability and efficiency of enterprises. The effect of System Average Interruption Duration Index on both profitability and efficiency were found to be negative. The firms in Odotei's study, however, were medium and large enterprises who were more likely to be energy-intensive than the micro-enterprise involved in the study of Peters, Sievert and Vance. The outcome lends support to the fact that the effects of electricity consumption on enterprise performance can be highly dependent on the location of the enterprise and level of energy intensity. Hence, there was the need to disaggregate the study of electricity consumption and performance to the industry level and to pay special attention to the manufacturing and service sector respectively.

Besides economic growth is considered the aggregation of industrial sector performance of which the service sector is a key components in the case of Ghana (Okuneye, 2019). Hence, the current study focused on the sectorial performance using the service sector but also evaluated the overall effects using the economic growth for the same period. The concentration on the service sector was motivated by impressive contribution of the sector to economic growth in Ghana. For example, the first quarter report of 2020 by the Ghana statistical Service(2020) stated that "The Services sector was the main driver of GDP growth contributing 3.6 percentage points (73.1%) to overall GDP growth rate of 4.9% in quarter one, 2020" (p.1). The service sector, therefore, promise to be possible solution to providing employment to the growing number of Ghana's labour force and hence demands attention in the research space.

Statement of the Problem

Productive use of electricity is mostly seen as a likely way to add to economic development. This is in view of the fact that availability of electricity allows firms to incorporate advanced production modes into their production lines, and hence increase the financial position of the enterprise through improved sales and possible cost reduction (Grimma, Hartwiga, & Layd, 2020). The heavy government investment into the energy sector of Ghana are justified on the ground that a stable energy supply in the form of electricity is that prerequisite to the industrialisation quest of the country (Blimpo & Cosgrove-Davies, 2019). The question, however, remains whether the continuous expansion of electricity indeed improve the performances of enterprises in the respective sectors?

In the Ghanaian context, attention has already been paid to the role of electricity consumption on performance in the manufacturing subsector with the least expected results. Abokyi, Appiah-Konadu, Sikayena and Oteng-Abayie (2018) examined the causal connection among electricity consumption and industrial growth in Ghana from 1971 to 2014. The study focused on the manufacturing subsector and found that as opposed to the popular view that electricity consumption increase productivity; electricity consumption has a statistical significant negative effect on the output of the manufacturing sector in Ghana. Though no study was cited in the service sector of Ghana, Mawejje and Mawejje (2016) studied the linkages between electricity consumption and sectorial output growth in Uganda. The outcome of the analysis indicated a long-run causality running from electricity consumption to service outputs. The analytic tool used by Mawejje and Mawejje (2016) could only point to the direction of causality but not the sign of the effects. The exact effects on electricity consumption on the service sector outputs, therefore, remains unresolved in a developing economy like Ghana.

The major motivation for this study was to examine the relationship that exists among electricity consumption, distributional losses and service sector performance with extension to national performance. The inclusion of the distributional losses was to accounts for the cost of producing, without using it for productive purposes, on sectorial and national performance. The level of distributional losses also have higher tendencies to influence electricity prices and again have implication on the green policy, which seeks for efficient use of energy (Amoako-Tuffour & Asamoah, 2015). The study also contributes methodological by identifying the estimation issues and making attempt to improve upon it for a more robust outcome. Jakovac (2018) lamented on methodological issues in the study of the linkages between electricity consumption and firm or economic performance which may affect the research outcomes significantly. According to Jakovac (2018), the lack of unanimity on whether economic growth leads to energy consumption or energy consumption results in economic growth may be due to differences in country characteristics, econometric methodologies employed and/or, difference in dataset used. This study attempted to address some of the methodological issues raised in the area of endogeneity and non-linearity of the relationship from econometric perspective.

Purpose of the Study

The purpose of the study was to evaluate the relationship among electricity consumption, distributional losses, service value added and GDP per capita growth rate in Ghana.

Research Objectives

The specific objectives of the study were to:

1. assess the relationship between electricity consumption and service value added in Ghana.
2. determine the relationship between electricity distributional losses and service value added in Ghana
3. examine the relationship between electricity consumption and GDP per capita growth rate in Ghana.
4. identify the relationship between electricity distributional losses on the GDP per capita growth rate in Ghana.

Research Hypotheses

The study tested the following working hypotheses

1. H0: There is no significant relationship between electricity consumption and service value added in Ghana.
2. H0: There is no significant relationship between electricity distributional losses and service value added in Ghana
3. H0: There is no significant relationship between electricity consumption and GDP per capita growth rate in Ghana.
4. H0: There is no significant relationship between electricity distributional losses on the GDP per capita growth rate in Ghana.

Significance of the Study

This study sought to understand the relationship among electricity consumption, distributional loses and micro and macro performance using service value added and GDP per capita respectively. The outcome of the study provides insight into the relative affordability of electricity to business in Ghana as well as it overall effects on the growth of the economy. The producers of electricity, Volta River Authority (VRA), transmitters, GRIDCo, and the distributors, Electricity Corporation of Ghana (ECG), or any assigned company may gain extra information of the real cost of high distributional losses to the firm and the economy at large. Policy makers at the government level shall also get enough inputs into energy policies especially, with regards to managing distributional losses.

Delimitations

The study evaluated the micro effects of electricity consumption and distributional losses using the service sector and the macro effects using the GDP per capita growth rate of Ghana. At the micro level, the scope was limited only to the service sector since the manufacturing sector have already receive attention from earlier studies. The period for the study was limited to 1988 to 2018, which was purely based on the availability of data on distributional losses. The measurement of sector performance was also limited to value added based on data availability since the study employed secondary data from the World Development Indicators (WDI) by the World Bank.

Limitation

The study like any other academic study was limited by time and resources. The richness of the data was also another limitation since it limits the depth of the analysis. The frequency of the time series data was also a limitation. A monthly frequency data would have served the interest of the study better but not all the variables could be accessed at that frequency, hence the conduct of the analysis at the annual level. The analysis of the study, however, made use of the ARDL approach which produces consistent results when the time series period is small.

Definition of Terms

Service value added: the difference between the revenue from sales and cost of all raw material used in the production of the quantities that were sold.

Per capita electricity consumption: the ratio of total annual electricity consumption to the population of Ghana for each year.

Per Capita GDP growth rate: the percentage change in the ratio of Gross Domestic Product (GDP) to the population of Ghana for each year.

Distributional losses: the percentage of generated electricity that could not make it to the final consumers for revenue generation on them. Singh (2009) define distribution losses as the difference between the volume of energy distributed to the distribution system and the volume of energy that consumers are actually billed. Thus, in the end every kilowatt lost incurred through system losses especially by the distributors (ECG) affect electric utilities charged to the consumer and the nation as a whole.

Organization of the Study

The study was divided into five chapters. Chapter One discusses the background, problem statement, purpose of the study, objectives of the study, significance, delimitation, limitation and organization of the study. Chapter Two examined the existing literature associated with the main themes of the study in order to gain insight in of the research topic. It reviewed the hypotheses on energy consumption and provides definition to key terms. Chapter Three consists of the research methodology employed in undertaking the study, which included the design and approach, data sources and description, model specifications and estimation among others. Chapter Four presents the results and the discussions to the study in line with the stated objectives. Lastly, Chapter Five summarizes the findings of the study and makes recommendations that would contribute in addressing the research problem raised, and suggested direction for further study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter reviewed the related theoretical and empirical literature on the relationship between electricity consumption and economic growth and industrial sector performance. It reviews the theoretical perspective, which included the hypotheses on the relationship between energy consumption and a framework on distributional losses and sector performance. It presents a brief outline of the electricity situation in Ghana and an empirical review after which a conclusion was offered.

Theoretical Review

The theories that govern the relationship between electricity/energy consumption and growth or performance are grouped into the hypotheses criteria (Apergis & Payne, 2009) and the generation criteria (Guttormsen, 2004).

Hypotheses criteria of Electricity consumption

The hypothesis approach analyses the relationship between electricity consumption and economic growth in the light of whether the outcome of studies concluded that electricity consumption causes economic growth or otherwise or both (Mensah et. al., 2016). Empirical studies on electricity-economic growth relationship have been clustered into four main themes as Growth-led-Energy, Energy-led- Growth hypothesis, Energy-led-Growth-led-Energy, and the Neutrality hypotheses.

The Growth-led-Energy hypothesis stresses that economic growth leads to energy consumption, which suggests that even critical energy crisis will not impede economic growth; hence, energy conservation measures are a viable option (Apergis & Payne, 2009). The Growth-led-Energy hypothesis simply suggests that causality moves strictly from economic or industrial growth to electricity or energy consumption. That is, it changes in growth prospects that facilitates the needs for expansion in energy infrastructure such that growth rate is a predictor of electricity consumption. Studies that align themselves with this hypothesis simply regress growth rate variables on energy consumption variables such as electricity consumption, coal consumption among others. Nguyen and Wongsurawat (2017) studied the connection between electricity consumption (EC), economic growth, exports (EX) and foreign direct investment (FDI) in Vietnam using time series data from 1980 to 2013. The results indicate that real GDP, EX, FDI and EC in Vietnam are co-integrated. This underpinned that there is one-directional Granger causality that run from real GDP to EX, FDI and EC.

The Energy-led-Growth hypothesis also suggests that energy consumption influence economic growth, which implies that severe energy crisis may impede economic growth; making energy conservation measures suboptimal decision. This hypothesis is simply the flip side of the growth-led-energy hypothesis since it basically suggest that it is energy consumption rather that predicts the level of economic and industrial development (Jakovac, 2018). The variances under this hypothesis revealed that, the level of energy consumption stimulates the needed economic development and that energy consumption must be considered the lead variables to economic growth and development. The studies that align themselves with this hypothesis essentially regress energy consumption variables such as electricity consumption, coal consumption among others on growth measures such as GDP growth rate or per capita GDP growth rate.

The Energy-led-Growth-led-Energy hypothesis suggests that there a bi-directional causality exist between economic growth and energy consumption. This hypothesis combines the position of the first two hypotheses by suggesting simultaneity between energy consumption and economic or industrial growth (Apergis & Payne, 2009). If the position of this hypothesis hold then both the Growth-led and energy-led position are right except that results from the two hypotheses cannot be viewed as contradictory but rather complementary. The major implication of the growth-led-energy hypothesis is in methodology. That is, if the hypothesis is consistent with reality, then studies under the growth-led and energy-led hypotheses must have issues with model specification or needed to address the issue of endogeneity arising from simultaneity (Amri, 2017; Apergis & Payne, 2009).

One way, researchers have dealt with the issues of model misspecification was to use the Vector Auto-regressive (VAR) model which treats both variables as endogenous. The application of the VAR framework, however, requires that all the variables are integrated of the same order which is not always true for economic variables such as GDP and energy consumption (Bayar & Özel, 2014). The introduction of the bound testing co-integration procedure address the issues of order of integration but fail to address the issue of simultaneity. In short, studies under this hypothesis must necessarily results to simultaneous equation modelling.

Bayar and Özel (2014) examined the association between electricity consumption and economic growth in the emerging economies during the period 1970-2011 by using Granger causality tests and Pedroni, Kao and Johansen co-integration tests. The analysis found that electricity consumption had a positive impact on the economic growth and there was bidirectional causality between electricity consumption and economic growth.

Lastly, the neutrality hypothesis suggests that there is no causal relationship between economic growth and energy consumption. That is, to say that if any relationship exist between energy consumption and economic growth, then there is more of indirect than a direct one (Apergisa & Payne, 2009). Hence, a direct regression between the two variables must turn out insignificant coefficient. Study that supported this hypothesis includes Banda (2017) and Khramova and Yao (2013). Banda (2017) examined the linkages between economic growth, electricity consumption and employment in Zambia from 1974 to 2016 using Vector Error Correction Model (VECM) with Impulse Response Function (IRF). The findings indicated that there is no causality between electricity consumption and economic growth, which confirmed the neutrality hypothesis.

Khramova and Yao (2013) examined the short-run and the long-run nexus between electricity consumption, economic growth, and FDI inflows in 17 emerging economies from 1992 to 2009 to aide optimal energy policy. The results indicated a long-run equilibrium relationship among electricity consumption, economic growth, and FDI. The outcome of the short run causalities indicated that the linkages between economic growth and electricity consumption are country specific, and must be appraised with care when designing energy policy.

There were studies that took all or a number of the hypothesis into consideration and made observation about a number of them. Omri (2017) concentrated on the various components of economic growth and energy consumption in terms of country coverage, modeling techniques, study periods, and empirical conclusions. The main findings were that outcome of the relationship are sensitive to methodology and type of energy consumption proxy used. The empirical results from the specific countries analysis were that:

1. for energy consumption-growth relationship: 27% supported the feedback hypothesis, 23% supported the conservation hypothesis, 29% buttressed the growth hypothesis, and 21% supported the neutrality hypothesis;
2. for the electricity consumption-growth relationship : 33% supported the feedback hypothesis, 40% supported the growth hypothesis, and 27% supported the conservation hypothesis;

Amri (2017) explained that these mixed results can be ascribed to the differences in the data used, econometric approaches and selected variables used for the analysis. Using a sample of 17 emerging countries, Destek and Aslan (2017) examined the link between economic growth and renewable energy consumption, and observed that while the neutrality hypothesis is empirically supported for 12 out of the 17 states, the growth-led hypothesis was validated only in Peru, the energy-led hypothesis only in Colombia and Thailand and the feedback (Growth-led-Energy-led) hypothesis was valid only for Greece and South Korea.

The current study was aligned with the Growth-led-Energy-led hypothesis since it was found to be applicable in developing countries. Hence, the estimation followed the simultaneous equation estimation to test the bi-causal relationship between energy consumption and economic growth.

Generation criteria for Electricity consumption and Economic Growth

According Guttormsen (2004) empirical works on energy-economic growth can be categorised along four lines as the first generation studies, second generation studies, third generation studies and fourth generation studies. The first generation studies consisted of the studies that employed the traditional Vector Autoregressive Models (Sims, 1972) and the standard Granger causality test. The major flaw associated with studies in this generation could be observe in the assumption that the time series data used need to be stationary (Adom, 2011). As a solution, studies in the second generation proposed the use of co-integration (Johansen & Juselius, 1990) as the suitable tool to be used in analysing the nexus between economic growth and energy consumption. Hence, in the second generation of studies, time series variables were tested for co-integration relationship and an error correction model were fitted to test for causality (Engle & Granger, 1987). Since the likelihood for more than one co-integrating vectors exist, the second generation studies approach was also considered inappropriate. This led to the third generation of studies, which suggested a multivariate approach that allowed for more than two variables in the co-integrating relationship. This approach also allowed estimations of systems where restriction on co-integrating relationship can be tested and information on short-run adjustment can be examined.

Two main problems emerged with the third generation studies (Adom, 2011). First is the restrictions imposed which requires that the time series variables should be integrated of order one. Secondly, the time series variables must be co-integrated before a test of causality could be done. It is, however, possible for some economic variables to be integrated of order zero or be stationary at levels. These led to the emergence of the fourth generation of studies. These studies use the Autoregressive distributed lag (ARDL) model proposed by Toda and Yomamoto Granger Causality test. Restrictions were not imposed on the variables in the analysis of studies under this generation. Hence, causality test was possible even if time series variables were where integrated of different orders (order zero, one or both).

To ensure reliable results, recent studies on the relationship between energy consumption and economic growth, use more current approaches such as threshold co-integration models (Hansen & Seo, 2002), ARDL Bounds co-integration test (Pesaran, Shin, & Smith, 2001), panel data models and simultaneous equation models (Adom, 2011). This study used the ARDL bound testing and the simultaneous equation model for the analysis based on their appropriateness to the study contest. The ARDL allowed for the use of time series variables integrated of different orders, while the simultaneous equation model allows for endogeneity resulting from simultaneity bias to be addressed.

The current study followed the generation study and hence used time series data on electricity consumption and economic growth to examine the relationship between the two variables. The inclusion of distributional losses was manly to control for efficiency in the use of electricity power generated.

Conceptual Review

Electricity generation usually undergo three-step phases before reaching the final consumer (Adom, 2011). First, electricity power is generated from generation thermals that are located away from the load centers. This generated power is then transmitted to the transmission grid, which consist of the transmission lines, transformers, and other components to the bulk load distribution substations (BLPSs). From the BLPSs electricity power is distributed to the individual customer through distribution lines.

In the case of Ghana, the three-step process is managed by three different entities. The Volta River Authority (VRA) is a SOE (state-owned enterprise) which solely responsible for the generation of bulk power electricity in Ghana. Currently, the VRA manages the two major hydro- power generation sources in the country, which are the Akosombo and Kpong hydro stations. Ghana Grid Company (GRIDCo) is in charge of transmitting power from bulk power plants to distribution lines while Electricity Company of Ghana (ECG) or more recently the Power Distribution Service (PDS) and Northern Electrical Department (NED), a subsidiary of VRA are tasked with distribution to the final consumer. ECG/PDS distributes electricity power to the southern half of the country while NED supplies power to the northern part of the country (Adom, 2011).

The total energy supplied in 2018 was about 15,960.36 GWh, comprising 6,017.36 GWh from hydro, 9,803.15 GWh from thermal and 139.70 GWh of Imports (Energy Commission, 2019). The generation mix at the end of the period was, therefore, 39.60% hydro, 58.14% thermal and 2.26% import. It is clear that the thermal sources now dominates in electricity generation sources of the country which change the narrative from weather dependence to financial dependency in terms of acquiring crude to power thermal plants. Since hydro sources are traditionally cheaper than thermal sources (Energy Commission, 2019), the generation mix explain why the electricity prices in Ghana keeps increasing after the 2007 and 2013 power crisis. The total system transmission losses recorded in 2018 was about 707.33 GWh which is 4.43% of total transmitted energy of 15,960.36 GWh, representing 19.01% increase over the projected transmission losses of 594.30 GWh (Energy Commission, 2019).

In 2017, the system recorded a total transmission losses of 587.11 GWh, which implies the 2018 losses represents a 1.2 % increase over the 2017 losses (Republic of Ghana, 2019). The growing significant percentage is a cause for concern. It could be noted that the losses in 2018 was about twice the electricity power imported from Cote d' Ivoire in the same period. Meaning by halving the transmission losses, Ghana could be power independent with no importation of energy.

The actual Ghana peak demand for 2018 was about 2,525.0 MW, which signified a growth of 17.01% or an increase of 367.0 MW over the 2017 peak of 2,158.0 MW (VRA, 2019). The total energy consumption including losses was 15,960.36 GWh as against a total of 14,308.08 GWh consumed for the same period in 2017, hence, the consumption in 2018 denoted a growth of 11.55% or 1, 652.28 GWh increase over that of 2017 (Energy Commission, 2019). The projected energy consumption including transmission system losses for 2019 is 17,237.79 GWh and 18,013.96 GWh for base and high case respectively. The base case consumption for 2019 compared to the 2018 actual consumption of 15,960.36 GWh represents a growth of 8% (1,277.43 GWh) (Energy commission, 2019). The total projected hydro generation for 2019 is 5,670 GWh (Energy commission, 2019). This would be made up of 4,258.44 GWh, 811.50 GWh and 650 GWh for Akosombo, Kpong and Bui Generating Stations respectively.

The Medium-Term (2020-2023) Demand and Supply Outlook from the power producers suggest that the country's electricity could be stable up until 2024 before additional install capacity may be needed. Figure 1 present the supply-demand outlook of the Ghana as projected into the future.

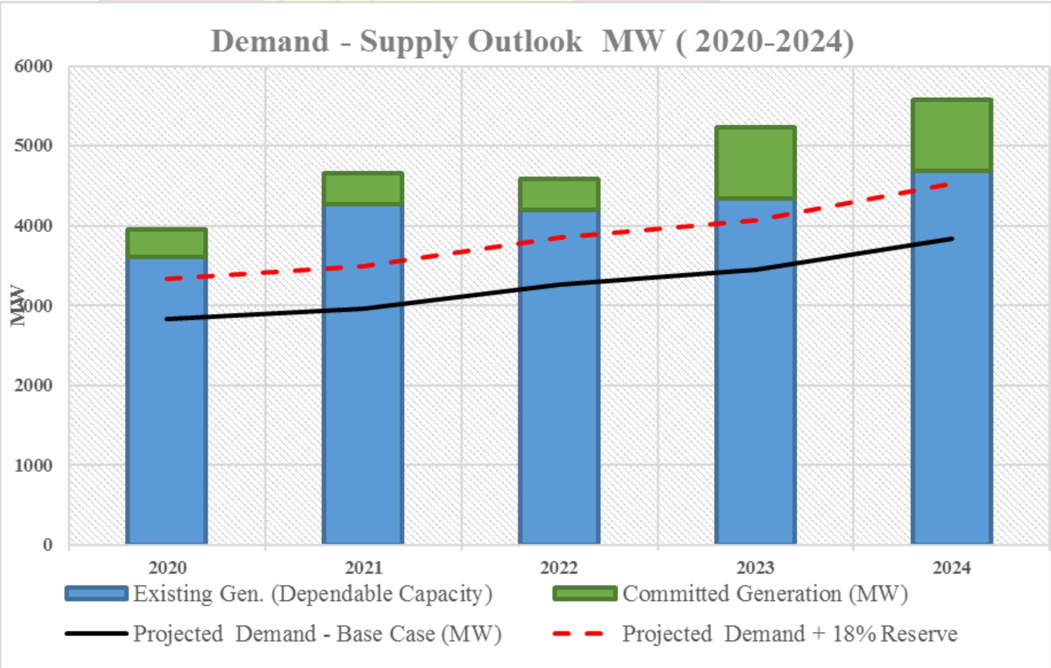

Figure 1- Electricity supply and Demand projection to 2024.

Source: Energy commission, (2019)

The projected demand could be seen in Figure 1 to be below the dependable capacity until 2024. If the trend indeed mimic the projection, then no power crisis are expected in the near future unless it has to do with finances to power thermal plants.

The most recent data suggest that the total estimated hydro generation for 2020 is 6,229 GWh, which is made up of 4,646 GWh, 819 GWh and 764 GWh for Akosombo, Kpong and Bui Generating Stations respectively (Energy commission, 2020). The estimated system peak demand for 2020 is 3,115 MW, which an increase of 11 % over the 2019 peak demand of 2,804 MW which was recorded on December 3, 2019 (Energy commission, 2020). The estimated energy consumption including transmission system losses for 2020 is 19,594 GWh.

This compared to the 2019 actual consumption of 17,887 GWh represents a projected growth of 9.5% (an increase of 1,707 GWh) (Energy commission, 2020). Hence, it was evidence from the overview that electricity consumption in Ghana has been on an increasing trend since independences and the trend is expected to continuous into the future. The need for sustainable and efficient use of electricity is therefore the way to go to avoid perennial power crisis.

Conceptual Framework

The link between energy consumption and economic and industrial performance are well documented as explained in the four broad hypotheses. The transmission mechanism from distributional losses to industrial sector performance, however, required some attention and this section provided a simple framework to explain the linkages.

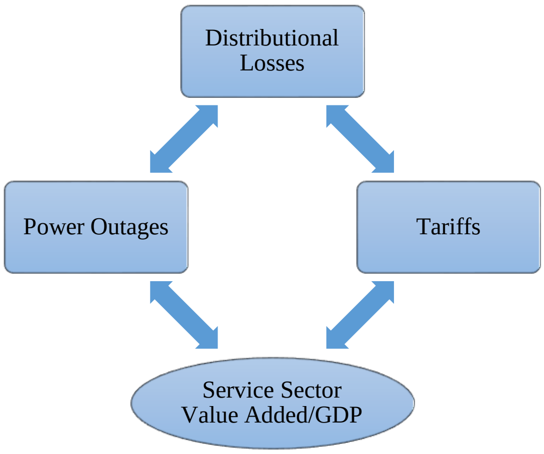

Figure 2-Conceptual Framework on Distributional Losses and Service Value Added.

Source: Field survey, (2021)

The framework in Figure 2 posits that the level of distributional loss can influence the supply and demand position of electricity. It is straight forward to assume that an increase in the percentage of distributional losses reduces the final units of electricity available to consumers and a reduction of the losses simple makes more units available to final consumers. Hence, though the issues of power outages and crisis are more of generation capacity, the level of distributional losses exacerbate the situation or prolong the period. Amoako-Tuffour and Asamoah (2015) indicated that high transmission and distribution losses cause the effective supply to fall significantly short of the available production capacity. The proportion of power outages that can be attributed to the distributional losses have direct effects on industrial values added.

In another development, increasing transmission and distributional losses means the remaining final consumption units must pay for the entire production cost, which shall translate into higher tariffs. Kumi (2017) identify a link between transmission and distribution losses by indicating that high levels of losses reinforce poor tariff structure to cause financial instability in utility companies of Ghana. The high tariffs can as well be felt by the level of power outages, which serves as the ground for service providers to push the Public Utility Regulatory Commission (PURC) for high tariff as a bait to improving services (Amoako-Tuffour & Asamoah, 2015). High or increasing tariffs have the tendency to push production cost up depending on the level of energy intensity. Greenstone (2014) indicated that where transmission and distributional losses are significant, “they may be a significant source of competitive disadvantage not only because firms face higher energy prices but also because electricity firms do not raise the revenue necessary to ensure a reliable supply of energy” (p. 13). In the Ghanaian context, high outages have implication for special tariff based on power intensity called special load tariff (SLT). The special load tariff (SLT) is the penalty on these electricity-intensive firms, when their power factor is below 90% (Amoako-Tuffour & Asamoah, 2015).

Lee, Lotsu, Islam, Yoshida and Kaneko (2019) examined the economic effect of an energy efficiency improvement policy on electricity-intensive firms in Ghana. The analysis used the regression discontinuity design (RDD) to the panel data from 1994 to 2012. The outcome indicated that a negative effects of the energy policy on salary and employment level of the firms in the long run, especially, the small- and medium–voltage firms. The findings further indicated that small and medium–voltage firms are economically weak to the penalty policy in the long run.

The conclusion drawn from the framework was that distributional losses has impact on industrial sector performance through several channels, popular among which are its effects on stable power supply and tariff adjustment on the demand side. The effects of distributional losses may not be monotonic negative since it could impact positively on industrial sector performance and hence economic growth. That is, where a greater proportion of distributional losses are as a result of unpaid illegal connection used by industries or industrial used of electricity at residential rate, there is the high tendency for distributional losses to indicate positive relationship with industrial sector performance (Lee at al., 2019). This possibility cannot be ruled out in the case of a developing country like Ghana.

Existing evidence in Ghana suggested that both companies and households are culprits in illegal power connections. For example, in Ashanti Region alone, the Electricity Company of Ghana (ECG) recovered more than GH¢21.5 million from companies and individuals which had illegally connected electricity to their premises in 2018 (Lee at al., 2019). One can imagine what the case will be for other region like Greater Accra, which has high business activities than the Ashanti Region.

Empirical Review

Electricity Consumption and Industrial/from Level Performance

The review on the hypothesis suggested that a lot of studies have been done on the relationship between energy consumption and economic growth. Through scan of the literature, however, indicate that the analysis at industrial and firm level have taken a different form. Since energy consumption values are normally not available at the firm and industrial level, the analysis has mostly taken the form of access to electricity and/or power outages and firm performance. The few studies that used energy consumption in aggregation used industrial value added as was done in this study. The inclusion of studies on power outages in the empirical review was under the assumption that electricity consumption reduces during such power crisis period, which services as an avenue to assess the effects on falling electricity consumption on industrial sector and firm performance.

Abokyi, Appiah-Konadu, Sikayena, and Oteng-Abayie (2018) investigated the causal relationship between electricity consumption and industrial growth in Ghana for the period of 1971 to 2014. Contrary to the popular view that electricity consumption influence productivity, the study reveals that electricity consumption has a negative impact on manufacturing sector output in Ghana.

Abeberese, Ackah and Asuming (2017) explored the effects of electricity outages on firm productivity using exogenous variation in outages across domestic small and medium scale enterprises in the manufacturing sector of Ghana. The analysis found that controlling for outages during the outage period could results in a 10 percent increase in the productivity of firm. Further analysis indicated that while strategies like using a generator, switching to less electricity-intensive production processes and changing production times are commonly used by firms, of which none of these strategies are able to shield firms from the negative effects of electricity crisis on productivity. It was discovered that one of the most frequently used strategies; use of generator, actually worsens the negative productivity effect by diverting firm capital from direct productive uses to the generation of electricity.

Odotei (2016) used a sample of seven firms selected for the study using convenience sampling technique and a panel data covering the period 2008-2012 adapted from the published financial statements of sampled firms. Data on power generation were time series data adapted from the Ghana Energy Commission spanning between the period 2008 and 2012. The results of the study suggested that stable electricity supply has a significant positive impact on both profitability and efficiency. The effect of System Average Interruption Duration Index (SAIDI) on both profitability and efficiency were found to be negative.

Peters, Sievert and Vance (2013) studied the effects of electricity usage on the microenterprises performance in the then Brong Ahafo Region of Ghana, employing cross-sectional firm-level data from the manufacturing and service sector. The results indicated that no statistical significant difference was observed between electricity usage and enterprise profitability.

Some authors have extended to the continental level by exploring the role of erratic energy consumption on firm performance across countries. Mensah (2016) attempts to estimate the firm level impact of power outages using panel data on firms from 15 Sub-Saharan African countries. The outcome from the analysis suggested that electricity shortages have significant negative effects on firm revenue and productivity. Finally, opposing to the notion that self-generation of electricity may be beneficial for firms during outage periods, evidence from the paper suggested that dependence on self-generation is associated with productivity losses notwithstanding the short run revenue gains. Abotsi (2016) also examined the effects of power outages on production efficiency of firms in Africa. The source of data was the World Banks' World Business Environment Survey. The analysis used stochastic production frontier and a two-tail Tobit models for estimation and analysis. The finding indicated that the number of power outages in a typical month affects the production efficiency of firms in Africa negatively.

Arlet (2017) tested the relationship between electricity sector characteristics and firm performance, using the Doing Business Getting Electricity (GE) indicator for 80 economies, using macro data on electricity tariffs and power outages. The analysis indicated that electricity outages impacts negatively on firm productivity. Electricity tariffs were also found to impact negatively on productivity but mainly for small and medium enterprises.

The inconsistency in the empirical results provides avenue for further querying of the relationship between electricity consumption and economic growth; which is what this study did.

Electricity Transmission and Distribution Losses and Industrial/Economic Performance

Adams, Klobodu and Lamptey (2017) assessed the impact of electric power transmission and distribution losses (ETL) on economic growth from 1971 to 2012 in Ghana. The analysis found a long-run relationship between electric power transmission and distribution losses but does not have robust impact on economic growth in the long run. Furthermore, electric power transmission and distribution losses indicated a threshold value of 2.07 percent in the studies. Finally, Klobodu and Lamptey found electric power transmission and distribution losses to moderates the relationship between economic growth and urbanization; higher ETL results in negative effect on GDP per capita when urban population was controlled for in the model. Elizalde (2013) also concluded after examining the key drivers and economic impact of non-technical losses in power distribution systems in Latin American countries concluded that economic development positively impact power distributional losses. Best and Burke (2018) studied electricity availability as a precondition for faster economic growth and discovered that transmission and distribution losses had significant negative effects on GDP per capita growth rate.

Chapter Summary

The review identified that the macro effects of electricity consumption on economic performance is well documented but a gap still exist in improving the methodology used in analyzing the relationship. In line with this observation, the study adopted a simultaneous equation, model to re-examine the nexus between energy consumption and economic growth in order to address the issue of simultaneity biased identified in existing systematic reviews. The empirical review further revealed that a gap still exist at the industrial level, especially in the service sector of Ghana, on the relationship between electricity consumption and sectorial performance. This study, again addressed this gap by examining the relationship between electricity consumption and service value added in the Ghanaian context.

CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter presents the methods used in conducting the study. The outline followed a research design and approach, data source and description, stationarity test, econometric model specification and estimation methods as well as optimal lag length selection.

Research Design

The study adopted a time series descriptive design to examine the relationship among macroeconomic factors, electricity consumption and electricity distributional loses. The time series descriptive design allows a researcher the option to examine the relationship among time series variables in the macro economy in order to obtain a vivid picture of the situation as they pertain in the social setting (Eisenhardt & Graebner, 2007). The design was suitable for this study because the main aim of the study aimed at assessing the relationship among the time series variables over a relatively long period. Hence, a non-experimental ex-post factor design such as the time series descriptive design was appropriate.

Research Approach

The study adopted the quantitative research approach based on the positivist philosophy. The quantitative design allows for rigorous statistical analysis of the relationship among the continuous time series variables and for the generalization of the outcomes. The positivist philosophy hypothesize that by using quantitative data for statistical analysis, it is possible to achieve value free research as was done in this study (Cresswell, 2014). The quantitative approach was appropriate for the study because the study adopted numerical data on the main selected variables over 34 year period which required testing of hypothesis and generalization of the outcome.

Data Source and Description

The time series data used for the analysis were retrieved from the database of the World Bank: World Development Indicators (WDI). The Economic database of the Central bank of Ghana has monetary data on financial variable at different frequencies ranging from daily to annual. The frequency of all the data sets was yearly spanning from the period 1984 to 2018, which gave 34 data points for the analysis. The choice of the time span for the data used was purely based on data availability as well as the need to confine the study to the period after the economic recovery programme (ERP) which ended in 1983. That, the Ghanaian economy was considered recovered and time series variable had their true meanings after the ERP.

Unit Root Testing

In order to avoid spurious regression normally associated with non-stationary time series data, the time series variables were tested for the presence of unit root. The study employed the Augmented Dickey-Fuller (ADF) unit root tests, which is an improvement over the Dickey-Fuller (ADF) unit root test. The ADF test assumes that the error terms are independent and identically distributed. The appropriateness for the ADF test was based on its flexibility in allowing for the inclusion of drift term or trend terms in the equation based on the observation of the time series plot. The testing process, therefore, started with the inspection of the time series plots for drift or trend stationarity before the ADF was eventually used as a formal test. The time series plot also provided avenue to observed the presence of structural break in a given time series variables. Where a structural break was suspected in the presence of non-stationarity, other test such as the Philip Perroni (PP) unit root test was used to confirm the presence of the unit root before differencing the variable.

The advantage that the PP test has over the ADF test is that the PP test can control serial correlation. The relevance of the unit root testing is to determine the stationarity and the order of integration of the variables since that was necessary for the determination of which model was appropriate.

Econometric MODEL SPECIFICATION and Estimation Technique

The study adopted a time series model specification for the estimation. The Bound testing autoregressive distributed lagged (ARDL) model was chosen over the traditional vector autoregressive and granger causality models due to the fact that the variables were not integrated of the same order as expected of macroeconomic variables. The application of the Vector Autoregressive Analysis (VAR) and Granger causality test rest on the assumption that the time series variables are integrated of the same order. A time series is integrated of order zero if it has a finite variance and a mean reverting property. It is only get temporarily out of equilibrium and return to stable equilibrium, and hence said to be stationary or I(0). However, a time series, that has to be differenced a number of before it is stationary is said to be non-stationary. The series is stationary at a higher order I (d), e.g. an I (1) series is stationary at first difference (as in Sheriff & Amoako, 2014).

The ARDL bound test procedure, however, allows for I(0) and I(1) times series variables to be used for long and short run models and still obtain consistent results (as cited in Adom, 2011), which makes it superior option where the variables are not integrated of the same order. In addition, size of the sample have little influence on ARDL bounds approach, which makes its small sample properties more superior to the multivariate co-integration approach. Finally, the ARDL approach is noted to providing unbiased long-run estimates even when some of the variables are endogenous. Narayan (2005) and Odhianbo (2009) as quoted in Amusa, Amusa and Mabugu (2009) concluded based on Narayan (2005) and Odhianbo (2009) that even when some of the explanatory variables are endogenous, the bounds testing approach generally results in consistent long-run estimates and valid t-statistics. The use of the ARDL approach was also appropriate for the study since it supports short times data such as the one used in this study.

The model followed the ADRL specification as presented in equation (1).

$$SVA_t = \alpha + \beta_1 SVA_{t-1} + \sum_{i=1}^{i=q} \beta_i E_{t-q} + \sum_{i=1}^{i=q} \gamma_i X_{t-q} + e_t \quad \ldots\ldots\ldots\ldots (1)$$

Where SVA is the service value added, E is the vector of electricity consumption and distributional losses, and X is the vector of control variables such as GDP per capital and log of investment expenditure. Also, the SVA_{t-1} is the first lag of service value added which was meant to determine the effects of the immediate past value of service value added on the current value of service value added. In short run model, β_1 services as the speed of adjust in the error correction model. The error term was represented by e_t, while α, β and γ are the slope coefficients or marginal effects. Also q represent the maximum lag which shall be determine using the AIC, FPE, LR and SBIC information criteria.

The second model had the GDP per capital growth rate (GDPPC_GR) was the dependent variables and was intended to capture the macro effects of electricity consumption and distributional losses.

$$GDPPC\_GR = \alpha + \beta_1 GDPPC\_GR_{t-1} + \sum_{i=1}^{i=q} \beta_i E_{t-q} + \sum_{i=1}^{i=q} \gamma_i X_{t-q} + e_t \quad \ldots\ldots (2)$$

All term and coefficient have the same meaning as in equation one.

Eventually, equations (1) and (2) were estimated together in a simultaneous equation framework. The estimation of the simultaneous equation model was to address the endogeneity problem which was anticipated to be a case of simultaneity bias.

Testing for Lag Structure (maximum lag length selection)

One of the difficulties in specifying an optimal lag length (ρ) for a model is that if it's select lag length that is too small, since it may lead to misspecification due to the omission of relevant variables and, it is possible the number of degrees of freedom may be lost if the chosen lag length is too large. That is, models with comparatively large number of lags is more likely to create residuals that approach the white noise process, but might not be parsimonious. On the other hand, models with smaller lag lengths are most likely to be parsimonious, but might not create residuals that are randomenough to approach a white noise process.

To resolve the aforementioned problem there is the need to select an optimal lag length ρ. The Akaike information Criteria (AIC) and Schwartz Bayesian information Criteria (BIC) are identified in literature as appropriate in selecting optimal lag lengths that results in residuals that approach a white noise process, subject to the constraint that the smallest number of lag terms will be selected for parsimony. The culture in optimal lag length selection is to select the lag that is selected by most information criteria when the FPE (Final Prediction Error) is added to AIC and BIC.

Chapter Summary

This chapter presented the design and approach used in conducting the study. It also provided information on the source of the secondary data used, the specification and justification for the model used for the analysis as well as some post estimation tests conducted.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter presents and discusses the analysis of the study using the adopted data and the proposed methods. It began with the summary statistics of the distributions of the main variables, followed by maximum lag length selection and unit root testing. It was then followed by the main analysis in line with the stated objective using the ARDL bound testing co-integration procedure. A brief discussion was done to specifically address the stated objectives from the results and to integrate the findings into the literature after which a chapter summary was provided.

Summary Statistics of the Main Variables

A brief summary statistics of the main variables was presented in Table 1. The study spans 34-year period from 1984 to 2018. The average electricity consumption per capital within the study period was about 308.68 KW with a very wide spread of about 71.20 KW. The wide spread can be explained by the observation that the minimum per capita consumption was about 92.78 KW while the maximum was about 445.20 KW which give a range of about 352.42 KW. The average GDP per capita growth rate was about 2.798 percent with a relatively wider spread of about 2.274 percent. The growth rate was lowest and negative at -0.114 percent in the year 2015 and highest at 11.32 percent in the year 2011.

Table 1: Descriptive Statistics of main Variable

Variable	Obs	Mean	Std. Dev.	Min	Max
Electricity consumption	35	308.68	71.78	9.28	445.2
GDP per capita	35	2.80	2.327	-0.11	11.31
Distribution loss	35	14.46	9.71	1.99	28.83
Electricity (hydro)	35	80.32	19.92	37.04	100
Gross capita formation	35	19,400,000	52,700,000	3.75	240,000,000
Service value added	35	1,820,0000,000	31,900,000,000	9,482,800	109,000,000,000

Source: Field survey, (2020)

The average distributional loss as a percentage of electricity power generated was about 14.46 percent with a spread of about 9.71 percent. The minimum distributional loss was observed to be 1.989 percent in the year 1999 while the maximum was as high as 28.834 observed in the year 2003. These average transmission and distributional loses was considered high in as compared to the expected average transmission and distribution losses of about 7 – 8% in developed countries (Omorogiuwa & Elechi, 2015). The average percentage of electricity generated from hydro-power sources was about 80.32 percent with a spread of about 19.92 percent. The minimum percentage was 37.75 percent observed in the year 2018, while the nation had relied full on electricity from hydro-power sources between 1987 and 1992. The average investment expenditure was about GH19.4 million Ghana cedis with a spread of 52.7 million Ghana cedis. Finally, the average service value added was about 18.2 billion with a very wide spread of 31.9 billion Ghana cedis. The fact that the spread exceed the mean value suggests a very erratic service value added distribution for Ghana. The value added was as low as 9,482,800.00 Ghana cedis in the year 1984 and as high as 109 billlion Ghana cedis in the year 2017. The relatively small service value added in 1984 is admissible since it was at the inception of the economic recovery program in Ghana while 2017 saw lows of service sector activities from expansionary policies of the state.

Lag Order Selection

Most time series estimations; including unit root testing, include the lag values of some of the variables. It was, therefore, necessary to determine the optimal number of lags that must be included for any time series variable during the estimations and testing. Table 2 presents the optimal lags selected by each of the standard information criteria.

Table 2: Optimal lag length selection

Selection-order Criteria			Sample: 2000q1 -2017q3				Number of obs = 26	
Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	-1631.3				3.0e+38	105.63	105.72	105.908
1	-1552.3	157.96	36	0.000	2.0e+37	102.857	103.49	104.8
2	-1514.8	74.906	36	0.000	2.4e+37	102.763	103.939	106.371
3	-1472.3	85.155	36	0.000	3.8e+37	102.339	104.058	107.612
4	-1277.5	389.43*	36	0.000	1.7e+34*	92.0991*	94.3609*	99.0378*

* Indicate optimal lag selected by the information criteria

Variables: Electricity consumption, GDP per capita, Distribution loss, Electricity (hydro), Gross capita formation and Service value added

Source: Field survey, (2021)

All the information criteria selected the fourth lag which makes it the optimal lag length for further estimates. Since the optima lag is the maximum lag that can be selected for any given estimation; the actual lag length in some estimation were much lower than the fourth lag.

Unit root test of the main variables

The GDP per capita growth rate, per capital electricity consumption, service value added and distributional loss as a percentage of total electricity generated were the main variables of the study. Figure 1 presents the time series plot of GDP per capita growth rate for the study period.

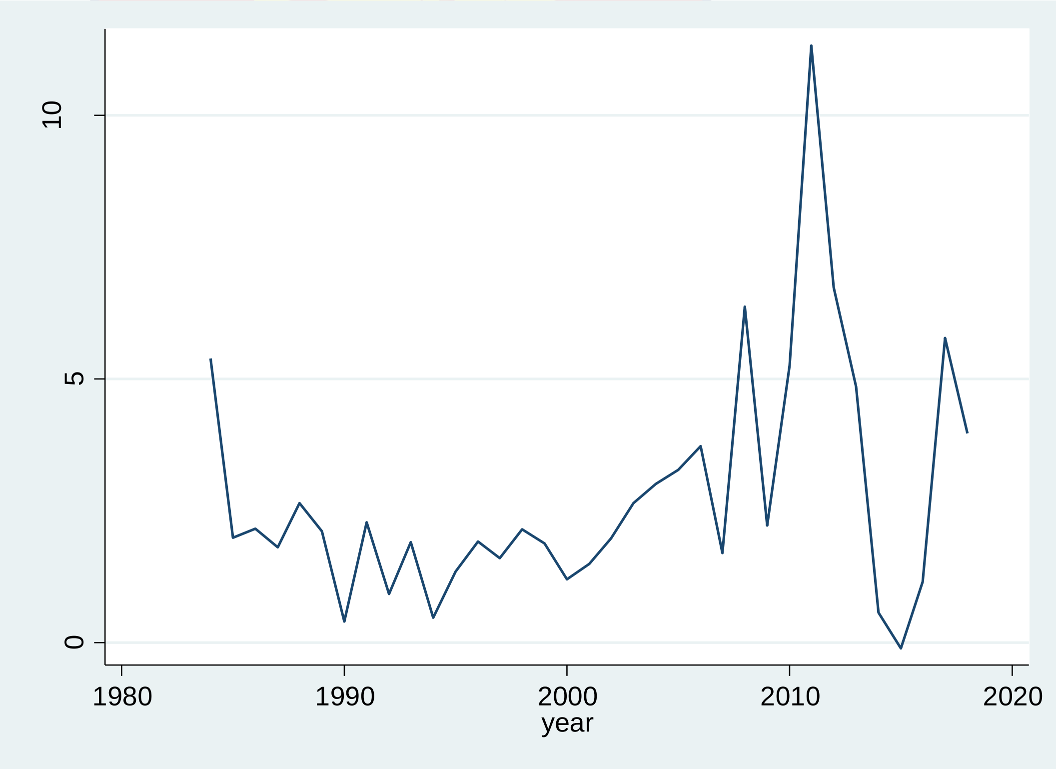

Figure 3-Time series plot of GDP per capita growth rate from 1984 to 2018

Source: Field survey, (2021)

The plot in Figure 3 showed a relatively drift graph of GDP per capita growth rate with the period of 1984 to 2018. The relative fluctuation in variable over the period points to a likely stationarity over the period, possible with a drift. Though, the fluctuations appeared to be more pronounced after 2010 but the fluctuation was both high in the rising and falling which rules out structural break. A formal test of stationarity was done using the ADF test and the results were presented in Table 3.

Table 3: ADF Test of Unit Root for GDP per Capita

Augmented Dickey-Fuller test for unit root		Number of obs = 34		
		Critical Values		
	Test statistics	1%	5%	10%
Z(t)	-3.553	-3.689	-2.975	-2.619

p-value for Z(t) = 0.0067

Source: Field survey, (2021)

The value of ADF test statistics was more negative than the 5 percent critical value which indicated that the null hypothesis of unit root present can be rejected at the five percent significance level ($p<0.05$). It was therefore concluded that the GDP per capita growth rate variable was stationary at level. That is the GDP per capita growth rate variable was an I(0) time series variable.

Figure 5 presents the time series plot of log of per capita electricity consumption variable.

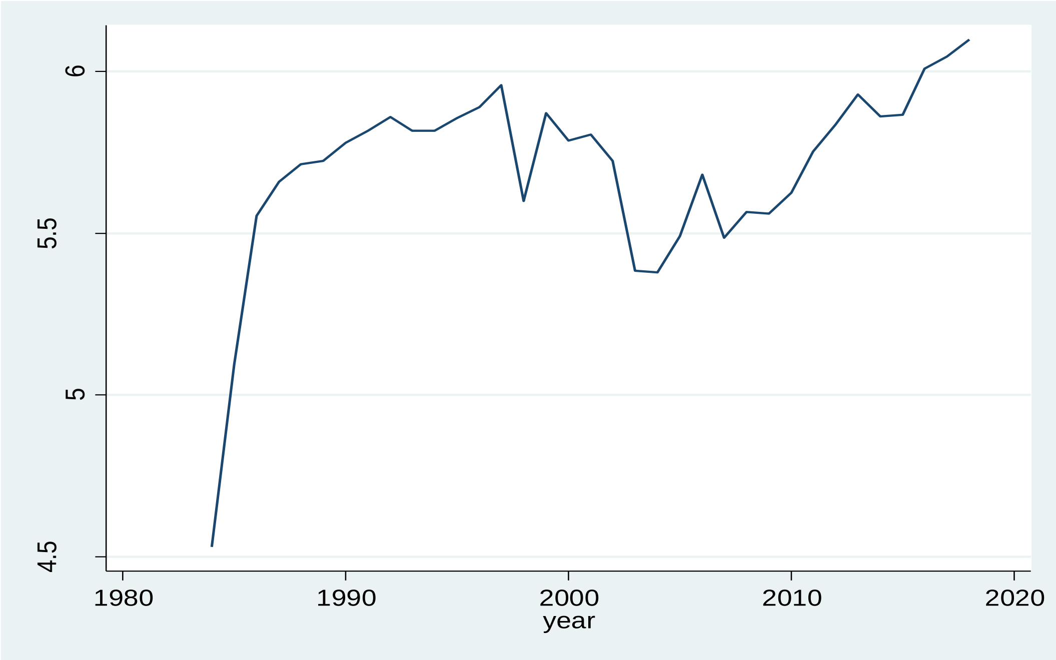

Figure 4-Time Series Plot of Logarithm of Electricity Consumption

Source: Field survey, (2021)

The line graph of electricity consumption per capita, as presented in Figure 3, indicated a very sharp rise in electricity consumption between 1984 and 1990 after which the consumption pattern exhibited a fluctuating time series trend. The trending pattern between 1984 and 1990 was likely to affects the stationarity of the time series variables but the ADF test, as presented in Table 4, lead to the conclusion that no such effects existed. That is, the structural break period was not long enough to affects the stationarity.

Table 4: ADF Unit Root Test of Electricity Consumption

Augmented Dickey-Fuller test for unit root		Number of obs = 33		
		Critical Value		
	Test statistics	1%	5%	10%
Z(t)	-5.295	-3.689	-2.975	-2.619

p-value for Z(t) = 0.0000

Source: Field survey, (2021)

The electricity consumption expenditure variable was also found to be stationary at the five percent significance level, which makes it an I (0) variables.

Figure 4 presents the time series plot of distributional lost variables over the study period.

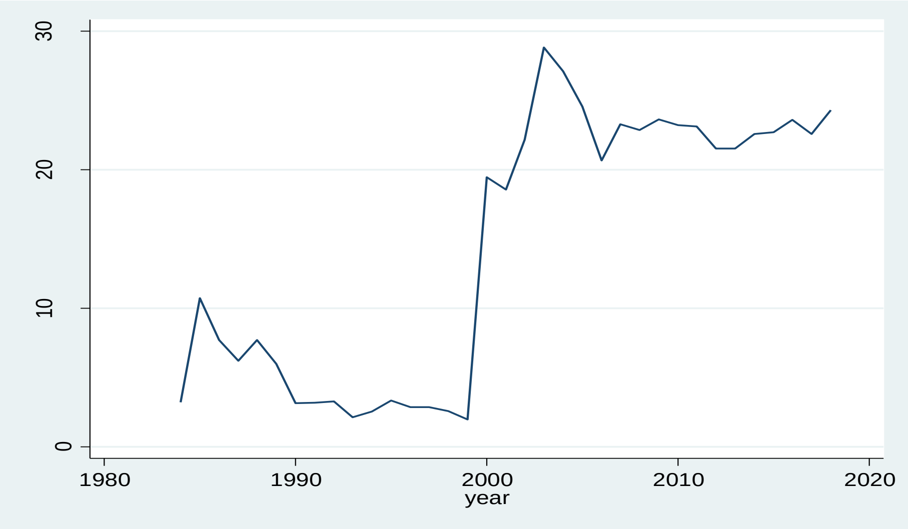

Figure 5-Time series plot of distributional losses
Source: Field survey, (2021)

The plot, as presented in Figure 6, suggest a structural break around the year 2000 which affected the stationarity of the time series variable. That is, the percentage of transmitted power lost or unaccounted for increases sharply from 1999 to 2000 and maintained a relatively high percentage till date. The initial ADF test of unit root on the level variable indicated the presence of unit root at the five percent significance level (p-value for Z(t) = 0.1189>0.05). The time series plot of the first difference of distributional losses is presented in Figure 5.

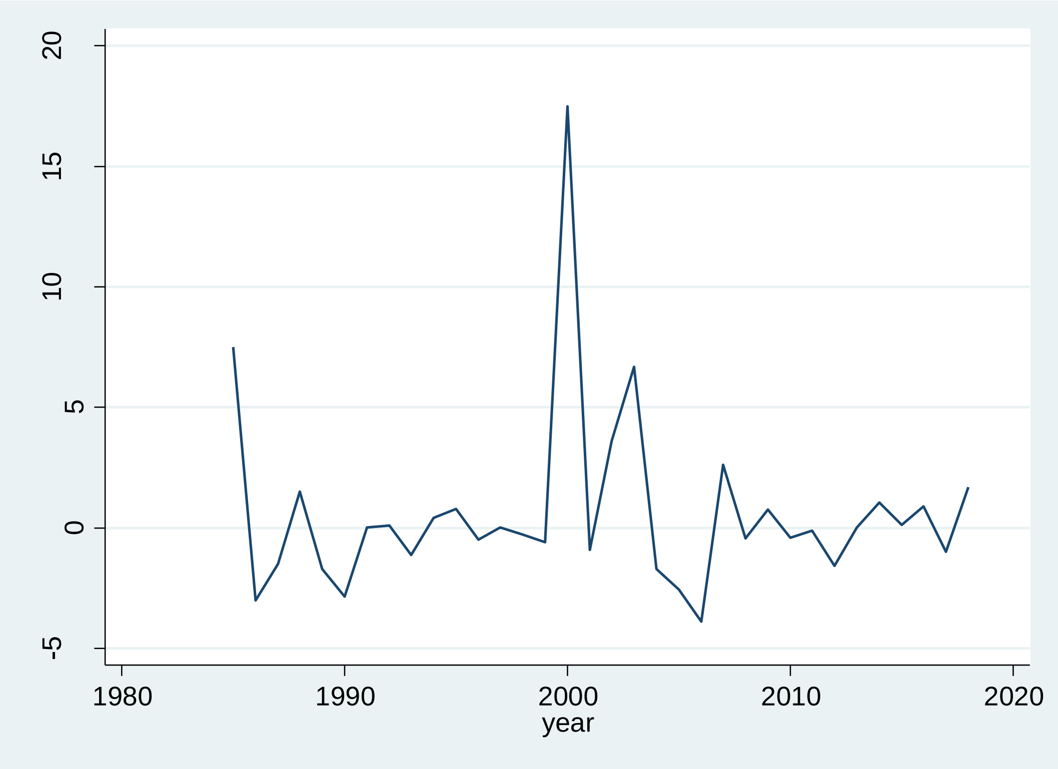

Figure 6-Time Series Plot of First Difference of Distributional Losses

Source: Field survey, (2021)

The traces of the structural break could still be seen in the plot of the first difference but the behaviour before and after the year 2000 appears to be consistent. The ADF unit root test outputs in Table 5 confirmed the stationary of the first difference of distributional loss variables.

Table 5: ADF Unit Root Test of First Difference Distributional Losses

Augmented Dickey-Fuller test for unit root		Number of obs = 33		
		Critical Value		
	Test	1%	5%	10%
statistics				
Z(t)	-6.441	-2.453	-1.696	-1.309

p-value for Z(t) = 0.0000

Source: Field survey, (2021)

The process lead to the conclusion that the distributional loss variable was an I(1) variable which is stationary only after first difference.

Figure 7 presents the time series plot of the log of the service value added.

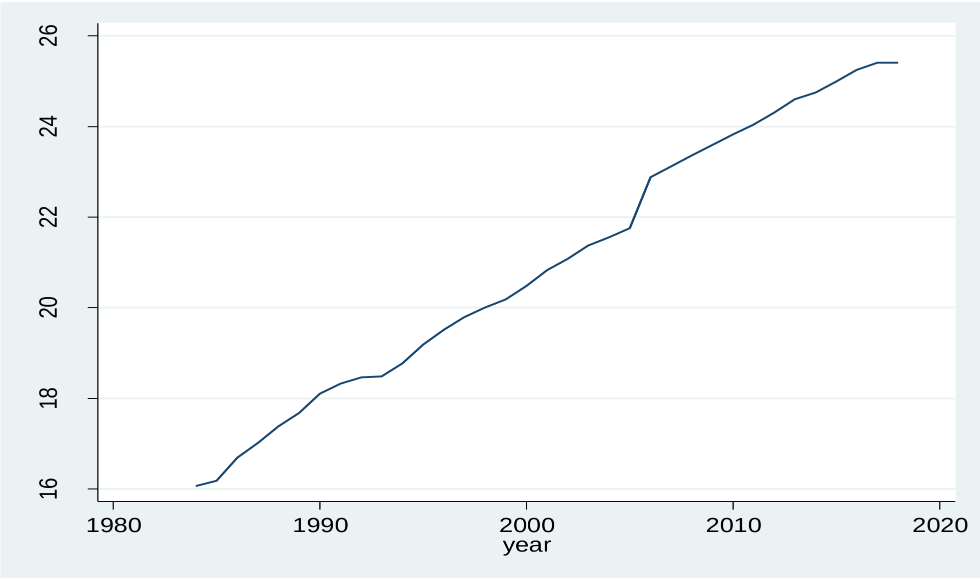

Figure 7-Time Series Plot of Service Value Added.

Source: Field survey, (2021)

The time series plot of service value added variable was trending within the study without much pronounced fluctuations. The unit root test using the ADF test identified the presence of unit root as it was suspected from the time series plot. The unit root test was extended to the first difference, which then became stationary as presented in Table 6.

Table 6: ADF Unit Root Test of Service Value Added

Augmented Dickey-Fuller test for unit root		**Number of obs = 33**		
		Z(t) has t-distribution		
	Test statistics	1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-5.577	-3.696	-2.978	-2.620

p-value for Z(t) = 0.0000

Source: Okyere, (2021)

The rest of the time series variables were test for stationarity, and the outcomes are presented in Table 7.

Table 7: ADF Unit Root Test for Control Variables

Variable	ADF test statistics	5% critical value	P-value for Z(t)	Decision
Hydro	-5.722	-1.696	0.0000	I(1)
Investment	-2.473	-1.708	0.0103	I(0)

Source: Field survey, (2021)

The test outcome in Table 8 indicated that the percentage of electricity from hydro time series variable was I(1) variable while the investment variable was an I(0) variable.

The unit root test confirmed the appropriateness of the model selected for the analysis since the time series variables are not integrated of the same order. The ARDL bound testing procedure allows for I(0) and I(1) variables to be included in the short and long run models for a consistent result.

Electricity Consumption, Distributional Losses and Service Values Added

The analysis started with the co-integration test to determine if stationary linear combinations of the variables exist. The bound testing co-integration procedure is a post estimation test after the estimation of the level ARDL model. Table 8 presents the output for the co-integration estimate with the in-built null hypothesis of *no level relationship*.

Table 8: ARDL Bound Testing of co-Integration

Pesaran/Shin/Smith (2001) Bounds Test		
H0: No level relationship		F=9.440
		t=-4.108
Critical value (0.1-0.01	F-statistics, case 1	

L_05	L_05
2.14	3.34

Accept HO if F<critical value of I(0)

Reject HO if F>critical value of I(1)

Source: Field survey, (2021)

The null hypothesis of no long run relationship could be rejected at the five percent significance level since the F value is greater than the 5% critical value of H(1) (F=9.44>3.34). Hence, the bound testing co-integration leads to the conclusion that a long run relationship exists among the variable at the 5% significance level. That is, at least one linear combination of the variables is stationary in the short-run which could result in a long-run equilibrium at some speed of adjustment. Hence, the estimation of Error Correction Model (ECM) model was done alongside the long-run model.

Table 9: Diagnostic Test of Error Correction and Long Run model

Number of obs = 31 R-squared = 0.9955 Adj R-squared = 0.9209 Root MSE = 0.0857
Serial correlation test : Durbin-Watson d-statistic(7, 31) = 2.434704 Heteroskedasticity test : chi2(1) = 0.01 Prob > chi2 = 0.9175 Ommitted variable test : F(3, 21) = 1.10 Prob > F = 0.3712 Mean VIF = 2.03

Source: Field survey, 2021

The first item of interest was the model adequacy check using the post-estimated tests. The Durbin-Watson test showed that there was no presence of first order serial correlation in the model since the d-statistic was approximately 2 based on the rule of thumb. Also, the null hypothesis of constant variances could not be rejected at the five percent significance level. It was therefore concluded that there was no issue with heteroscedasticity with the model, which was confirmed by the variance inflation factor (VIF) mean of 2.03 which is less than 10. Again, the null hypothesis of no omitted variable could not be rejected at the five percent significance level. The model had an R-square of about 0.9955, which indicate high predictive power of the explanatory variables. The relatively close Adjusted R-square value confirms the relative fitness of the model for interpretation and policy recommendations.

Finally, the stability of the model was assessed using the cumulative sum square as presented in Figure 7.

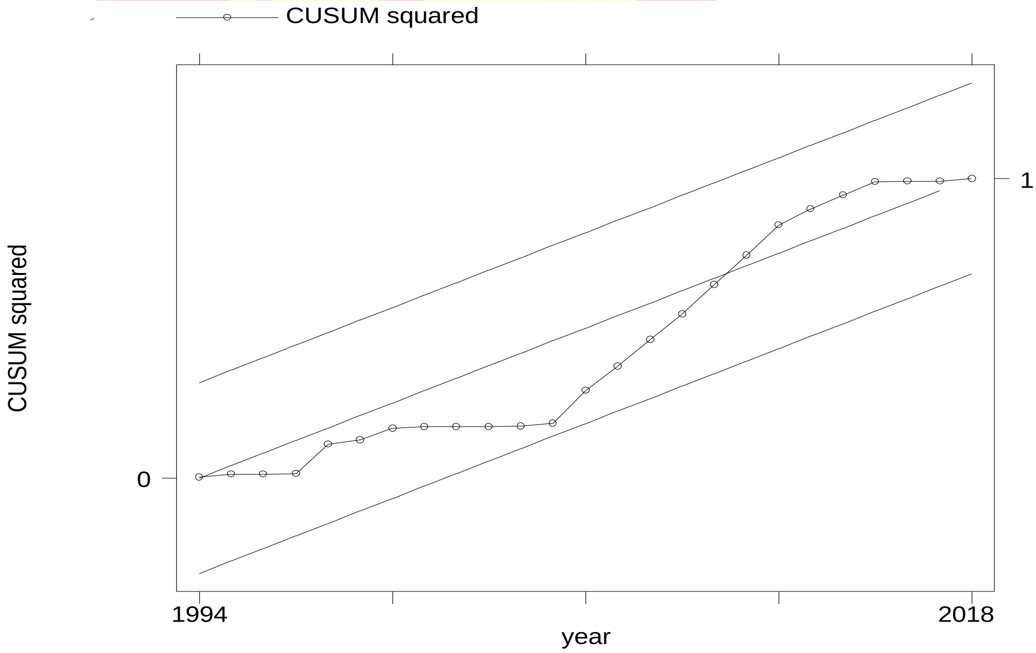

Figure 8- Stability plot of the ARDL model

Source: Field survey, 2021

The stability plot lies within the 95 percent confidence interval bounds, which indicates that the model is stable for further analysis.

Table 10: Short and Long Run ARDL Model of GDP per Capita Growth

Variable	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Speed of adjustment (ADJ)	-.5529591	.1346078	-4.11	0.054	-1.13213	.0262114
Long Run model						

GDP per capita growth rate (L1.)	.8184289	.0721016	11.35	0.008	.5082009	1.128657
Electricity consumption (L1.)	.0254332	.0017054	14.91	0.004	.0180953	.0327711
Investments (L1.)	-.0815708	.0231978	-3.52	0.072	-.1813828	.0182412
Distributional loss (L1.)	.2860945	.0144516	19.80	0.003	.2239144	.3482746
Hydro-electricity (L1.)	.0848293	.0081884	10.36	0.009	.0495974	.1200613
Short Run model						
Service value added						
LD.	.7600497	.4123482	1.84	0.207	-1.014141	2.534241
L2D.	-.4592313	.2185534	-2.10	0.170	-1.399591	.4811281
L3D.	1.104939	.2720062	4.06	0.056	-.065409	2.275287
GDP per capita growth rate						
D1.	.2419542	.0725856	3.33	0.079	-.0703564	.5542647
LD.	-.2246237	.0637506	-3.52	0.072	-.4989206	.0496732
L2D.	-.2792336	.0782962	-3.57	0.070	-.6161149	.0576478
L3D.	-.1557976	.0430913	-3.62	0.069	-.3412044	.0296091
Electricity consumption per capita						
D1.	.0013832	.0010328	1.34	0.312	-.0030606	.0058271

Table 10: Continued

LD.	-.0069169	.003399	-2.04	0.179	-.0215415	.0077076
L2D.	-.0000944	.0012351	-0.08	0.946	-.0054086	.0052197
L3D.	-.0084385	.0026341	-3.20	0.085	-.0197723	.0028953
Investment expenditure						
D1.	-.0226097	.0116767	-1.94	0.192	-.0728505	.027631
LD.	.0766184	.0178272	4.30	0.050	-.0000857	.1533225
L2D.	.0509009	.0095571	5.33	0.033	.0097802	.0920216
L3D.	.0475228	.0082639	5.75	0.029	.0119659	.0830797
Distributional and transmission _losses						
D1.	.1133904	.0300214	3.78	0.063	-.0157811	.242562
LD.	-.193213	.0492064	-3.93	0.059	-.4049309	.0185048
L2D.	-.0434562	.015992	-2.72	0.113	-.1122641	.0253518
L3D.	-.076259	.019384	-3.93	0.059	-.1596617	.0071437
Electricity hydro sources						
D1.	-.0036864	.0049941	-0.74	0.537	-.0251742	.0178013
LD.	-.0680604	.0127346	-5.34	0.033	-.1228527	-.013268
L2D.	-.0228343	.0069629	-3.28	0.082	-.0527933	.0071246
L3D.	-.072395	.0190613	-3.80	0.063	-.154409	.0096193

Key: L=lag, D =difference and LD= lag difference

Source: Field survey, (2021)

From Table 10, the error correction term (ADJ) was marginally significant at the ten percent significance level. The result was negative and less than one which suggest that the model is stable and all deviations in the system can be corrected in the present period.

The long run model estimated the effects of up to the first lag of the explanatory variables on service value added. The outcome suggested that the first lag of GDP per capita growth rate had direct significant effects on service value added. Numerically, a one percent increase in per capita GDP increase the service value added by about 81.843 cedis if all other factors remain constant.

The results on electricity consumption indicated that a kilo-watts increase in per capita electricity consumption has the tendency to increase the service value added by about 0.025 cedis when all other factors are kept constant. Interestingly, the first lag of distributional losses had direct significant effects on service value added in Ghana. This results was counter intuitive but not without possible explanations. In a developing country like Ghana, it could be expected that a part of the loss are actually *free ride* in the service sector through illegal connections. Though, the secondary data used had no data to substantiate this claim but it remains a possible explanation to the direct observed relationship between the first lag of distributional losses and electricity consumption.

Another interesting observation was the fact that an inverse relationship was observed between investment and service value added. Economic and finance theories hold that investment should have direct effects with outputs but its effects on value added as a component of GDP is far from clear. That is, through the possibility of high cost of capital, the crowding out effects can results in a negative relationship between investment and value added as it was observed in this study.

Finally, the percentage of electricity from hydro-power sources had direct and significant effects on service value added in the Ghanaian context. This observation could be explained by the obvious fact in Ghana where the electricity price has between increasing with the fall in hydro-power share in total electricity generated in the past decades. This, in part, could be due to the fact that the other sources of electricity depends largely on oil which have very erratic price regimes in Ghana.

Table 10 presents the short run model which has difference and lag difference variables as explanatory variables. The variable of greatest interest in the short run model is the first difference variable which actual represents the spread in the variable in question. The results suggested that the first difference of GDP per capita and distributional losses were marginally significant at ten percent significance level. It was concluded that a percentage increase in the spread of GDP per capita has the tendency to increase the service value added by about 24.2 percent in the same direction. The outcomes of the lag difference variables were however negative, which point to a very small positive effects as it was observed in the long run model for GDP per capita. Similarly, the first difference of the distributional losses variables indicated a direct effects on service value added but the lag difference variables had negative effects. Though, the first difference of electricity consumption was not statistically significant at predicting service value added; but all the lag difference up to the third lag difference had significant positive effects on service value added. Also, the first to third lag difference of the hydro-power variable had negative significant effects on service value added. Only the third lag of the service value added had significant direct effects on serve value added.

The major conclusion from the short-run model was that the explanatory variables, especially, electricity consumption and GDP per capita growth rate, exhibited long memory in terms of their effects on service value added.

Electricity Consumption, Distributional Losses and GDP per capita growth rate

Table 11 presents the output for the co-integration estimate of the model with GDP per capita growth rate as the dependent variable. .

Table 11: ARDL Bound Testing of co-Integration

Pesaran/Shin/Smith (2001) Bounds Test		
H0: No level relationship		F=704.525
		t=-21.925
Critical value (0.1-0.01	F-statistics, case 1	
L_05	L_05	
2.62	3.79	

Accept HO if F<critical value of I(0)
Reject HO if F>critical value of I(1)
Source: Field survey, (2021)

The null hypothesis of no long run relationship among the variables could be rejected at the five percent significance level since the F value is greater than the five percent critical value of H(1) (F=704,525>3.79). Based on the outcome of the bound testing co-integration it was concluded that a long run relationship exist among the variable at the five percent significance level. That is, at least one linear combination of the variables is stationary in the long run which could result in a long run equilibrium at some speed of adjustment. Hence, the Error Correction Model (ECM) model was estimated for the model with GDP per capita as the dependent variable as presented in Table 12. The Table presents the major model diagnostic or adequacy test of the ARDL error correction model.

Table 12: Diagnostic Test of Error Correction Model of GDP Per Capita Growth Rate

	Number of obs = 31
	R-squared = 0.9988
	Adj R-squared = 0.9811
	Root MSE = 0.3261
Serial correlation test : Durbin-Watson d-statistic(30, 31) = 2.543014	
Heteroskedasticity test : chi2(1) = 1.04 Prob > chi2 = 0.3088	
Ommitted variable test : F(3, 4) = 6.09 Prob > F = 0.0567	
Mean VIF = 4.36	

Source: Field survey, (2021)

The first item of interest was the model adequacy check using the post-estimated tests. The Durbin-Watson test showed that there was no presence of first order serial correlation in the model since the d-statistic was approximately 2, based on the rule of thumb. Also, the null hypothesis of constant variances could not be rejected at the five percent significance level. It was therefore concluded that there was no issue with heteroscedasticity with the model, which was confirmed by the variance inflation factor (VIF) mean of 4.36. Again, the null hypothesis of no omitted variable could not be rejected at the five percent significance level. The model had an R-square of about 0.9988, which indicate high predictive power of the explanatory variables. The relatively close Adjusted R-square value of 0.9811 confirms the relative fitness of the model for interpretation and policy recommendations.

Finally, the stability of the model was assessed using the cumulative sum square as presented in Figure 9.

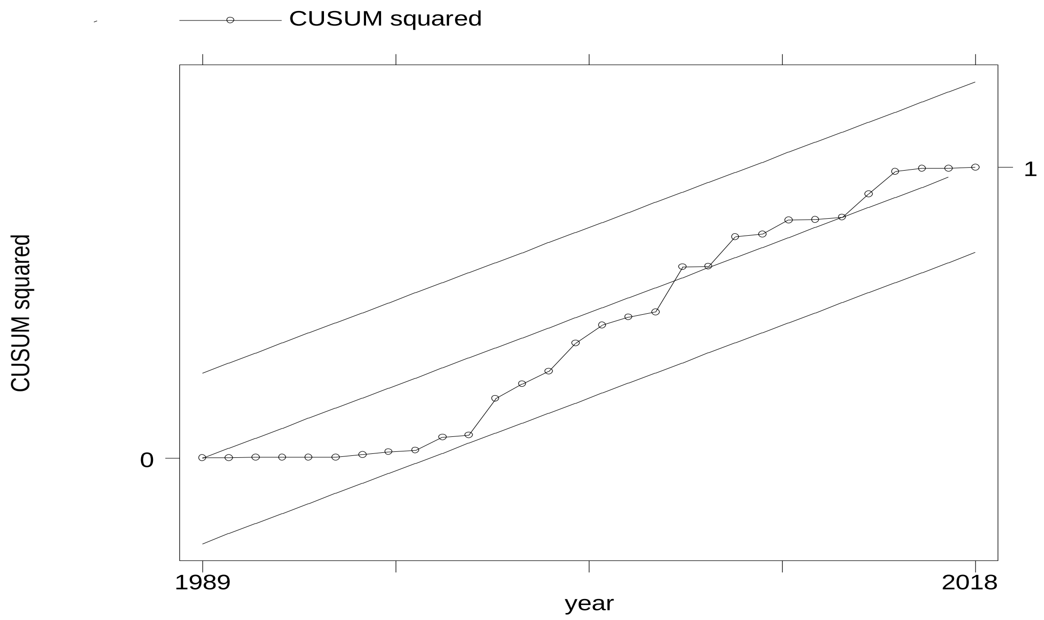

Figure 9-Stability plot of the ARDL model

Source: Field survey, (2021)

The stability plot lies with the 95 percent confidence interval bounds, which indicates that the model is stabile for further analysis.

Table 13: Short and Long Run ARDL Model of GDP Per Capita Growth

Variable	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Speed of adjustment (ADJ)	-1.86512	.0860983	-21.66	0.002	-2.235571	-1.494669
Long Run model						
Elect. cons (L1.)	-.0307358	.0027784	-11.06	0.008	-.0426902	-.0187815
Service VA (L1.)	1.185405	.0954626	12.42	0.006	.7746629	1.596148
Investment exp.	.0920442	.0303391	3.03	0.094	-.0384945	.222583

(L1.)						
Dist. losses (L1.)	-.3326997	.0412525	-8.06	0.015	-.5101948	-.1552046
elect_hydro (L1.)	-.0970086	.014095	-6.88	0.020	-.1576546	-.0363626
Short Run model						
GDP per capita growth rate						
LD.	.9141559	.0787117	11.61	0.007	.5754867	1.252825
L2D.	1.138338	.0720998	15.79	0.004	.8281179	1.448559
L3D.	.6326915	.049193	12.86	0.006	.4210309	.8443521
Electricity consumption per capita						
D1.	-.0041731	.0045369	-0.92	0.455	-.0236937	.0153476
LD.	.0307063	.0064887	4.73	0.042	.0027878	.0586248
L2D.	.0009529	.0046576	0.20	0.857	-.019087	.0209927
L3D.	.0337048	.0069172	4.87	0.040	.0039425	.0634672
Service value added						
D1.	3.502564	1.05076	3.33	0.079	-1.018489	8.023618
LD.	-3.446676	.8383704	-4.11	0.054	-7.053893	.1605409
L2D.	1.878028	.6741137	2.79	0.108	-1.022449	4.778505
L3D.	-4.302284	.808159	-5.32	0.034	-7.779512	-.8250565
Investment expenditure						
D1.	.0873639	.0431002	2.03	0.180	-.0980813	.272809
LD.	-.3029199	.0347943	-8.71	0.013	-.4526277	-.153212
L2D.	-.1919875	.040568	-4.73	0.042	-.3665374	-.0174376
L3D.	-.1757131	.0435624	-4.03	0.056	-.3631469	.0117207
Distributional and transmission losses						
D1.	-.4566627	.0428882	-10.65	0.009	-.641196	-.2721295
LD.	.7764704	.0616768	12.59	0.006	.5110964	1.041844
L2D.	.1674623	.0578707	2.89	0.102	-.0815353	.4164599

L3D.	.3027828	.0411476	7.36	0.018	.1257388	.4798267
Electricity from hydro sources						
D1.	.0128075	.0194266	0.66	0.577	-.0707784	.0963934
LD.	.2616636	.0405212	6.46	0.023	.0873149	.4360122
L2D.	.0884557	.0237405	3.73	0.065	-.0136915	.1906029
L3D.	.2920938	.0231329	12.63	0.006	.1925611	.3916266

Source: Field survey, (2021)

From Table 13, the error correction term (ADJ) was marginally significant at the ten percent significance level. The coefficient of the error correction term was negative and less than one which suggests that model is stable such that the system shall adjust itself of all deviations in the present period. The outcome suggested that the first lag of service value added had direct significant effects on GDP per capita growth rate. Numerically, a one percent increase in service value added can increase the per capita GDP growth rate by about 1.19 percentage points, if all other factors remain constant.

The results on electricity consumption indicated that a kilo-watts increase in the per capita electricity consumption has the tendency to decrease the GDP per capita growth rate by about 0.03 percentage points when all other factors are kept constant. The first lag of distributional losses had negative significant effects on the GDP per capita growth rate in Ghana. The outcome confirmed the detrimental effects of increasing percentage of generated power lost during distribution on the economic growth rate and the welfare of the citizens of Ghana. Investment had the expected direct significant effects of investment on economic growth and welfare variable like GDP per capita growth rate in Ghana. An interesting observation made was the inverse relationship between percentage of electricity generated from hydro-power sources and GDP per capita growth rate.

The outcome from the short run model suggested that the first, second and third lag differences of GDP per capita growth had positive effects on current level of GDP per capital growth rate at the five presence level. The first difference of electricity consumption was again not statistically significant at determining GDP per capita growth rate; but all the first lag and third lag differences had significant positive effects on GDP per capita growth rate. Interestingly, the first and third lag difference had almost identical effects on GDP per capita growth rate which suggest that the GDP per capita growth rate has a long memory. The first difference of the service value added had positive significant effects on GDP per capita growth rate but the lag difference had almost identical negative effects which points to the very small effects in the lag variable in the long run model.

The first difference of the distributional losses variables indicated a significant negative effects on GDP per capita growth rate but the first lag and third differences had positive effects on GDP per capita growth rate. The magnitudes of the positive and negative effects points to the rationale behind the very small negative effects observed in the long run model. Also, the first to third lag difference of the hydro-power variable had no statistical significant effects on GDP per capita growth rate. However, the first three lag of GDP per capita growth rate had direct effects on the GDP per capita growth rate.

The major conclusion from the short run model was that the explanatory variables, especially, electricity consumption and GDP per capita growth rate, exhibited long memory in terms of their effects on GDP per capita growth rate.

Analysis of the simultaneity among electricity consumption, distributional losses and service value added

The study tested third and fourth hypotheses by estimating the simultaneity between energy consumption and GDP per capita growth rate and extended it to include the transmission and distributional losses. Table 14 presents the model diagnostic used to determine the model adequacy before interpretation.

Table 14: Model Diagnostic of Simultaneous Equation Model

Equation	Obs	Parms	RMSE	R-square	Chi-square	P-value
GDP per capita growth rate	35	4	1.982922	0.2172	21.80	0.0002
Electricity Consumption	35	4	49.30584	0.5064	102.29	0.0000
Distributional losses	35	4	4.379026	0.7908	199.97	0.0000

Source: Field survey, (2021)

Two major model post estimation test were recommended in the literature after SURE simultaneous equation model, which were the R-square and the Wald test of overall significance. The R-square values suggested the distributional losses equation was the model well fit (79.08%) followed by the electricity consumption mode (50.64 %) with GDP per capita equation having an R-square of 21.72 percent. the low R-square could be attributed to the fact that some important drivers of GDP were not included. Despite having the least R-square value, the model with GDP per capita is dependent variable had the least root mean square error of which adds to its adequacy as a model. The Wald test of overall significant found all the model to be adequately better than an empty model. The three models were all adjudged fit for interpretation and policy recommendations. The models are presented in Table 15.

Table 15: Simultaneous Equation Model for all Three Endogenous Variables

Variables	Coef.	Std. Err.	z	P>z
GDP per capita growth rate				
Electricity Consumption	-0.0227969	.0065487	-3.48	0.000
Distributional losses	-0.1850282	.0761877	-2.43	0.015
Log of service vale added	1.148112	.3014749	3.81	0.000
Log of Investment expenditure	0.1267844	.0750323	1.69	0.091
constant	-12.27249	4.759668	-2.58	0.010
Electricity Consumption				
GDP per capita growth rate	-12.71914	3.65375	-3.48	0.000
Distributional losses	-9.96353	1.215881	-8.19	0.000
Log of service vale added	42.81437	5.317866	8.05	0.000
Log of Investment expenditure	2.294261	1.797461	1.28	0.202
constant	-422.6026	103.8656	-4.07	0.000
Distributional losses				
Electricity Consumption	-.0817971	.009982	-8.19	0.000
GDP per capita growth rate	-.8475083	.3489723	-2.43	0.015
Log of service vale added	4.010814	.3448507	11.63	0.000

Log of Investment expenditure	.2481139	.1582027	1.57	0.117
constant	-43.43702	7.428354	-5.85	0.000

Source: Field survey, (2021)

The first model in Table 15 had the GDP per capita been the dependent variable. The results indicated that electricity consumption has negative significant effects on GDP per capita growth rate at the five percent significance level. The outcome confirmed the earlier observation about the first lag of electricity consumption in the ARDL model. The volume of transmission and distributional losses had significant negative effects on GDP per capita growth rate in Ghana. Unlike the case of energy consumption, the negative effects of distributional losses was consistent with apriori expectations. The results indicated that a percentage increase in the transmission and distributional losses can reduce the per capita growth rate by about 0.03 percent annually. For purpose of forecasting, it could be concluded that a mean annual transmission and distributional losses of about 14.46 percent translates to about 0.4338 percent annually. Given that the mean GDP per capita growth rate for the period was 2.80, the losses was considered significant enough to merit the attention of policy makers.

Investment expenditure was marginally significant at the ten percent significance level. The outcome indicated an expected positive effects of the gross domestic fixed capital formation (investment) on the GDP per capita growth rate such that a cedi increase in gross domestic fixed capital formation has the tendency to increase the GDP per capita growth rate by about 0.13 percent. Also, service value added indicated a significant positive effects on the GDP per capita growth rate.

The second model had electricity consumption as the dependent variable. The results confirmed the negative significant relationship between electricity consumption and GDP per capita growth rate. The results suggested that a percentage increase in GDP per capita is accompanied by a 12.72 KW reduction in per capita of public electricity consumption. As it was expected, the volume of distributional losses indicated a negative relationship with electricity consumption such that a percentage increase in distributional losses as a percentage of GDP can reduce the per capita electricity consumption by about 9.96 KW annually. Service value added had significant positive effects on electricity consumption such that a cedi increase in service value added can increase the per capita electricity consumption by about 42.81 KW. Gross domestic fixed capital formation had not statistical significant impact on per capita electricity consumption.

Model three had the transmission and distributional losses as the dependent variable. The results showed negative significant relationship between distributional losses, per capita electricity consumption and GDP per capita growth rate. Again a positive relationship was observed between service values added and distributional losses in Ghana. The same observation was made in the ARDL model which adds to the validity of the direction of effects which is a positive relationship as against an expected negative relationship.

The simultaneous equation model confirmed the earlier observation the ARDL model in terms of sings of the association though same slight differences could be observed between the magnitudes of the effects.

Discussion of Main Findings

The analysis provided information to address the stated objectives. The first objectives of the study was to assess the effects of electricity consumption on service value added in Ghana. This objective was to examine the micro effects of per capita electricity consumption on economic performance. The analysis lead to the conclusion that per capita electricity consumption had direct effects on service value added in the service sector of Ghana. The existence of such long run relationship was confirmed by the significant adjustment coefficient or error correction term, which proves the system was stable over time. That is, short run deviations are adjusted or corrected in the long run to achieve a stable equilibrium on the relationship between electricity consumption and service value added in Ghana. The positive effects of electricity consumption on service value added was robust to the choice of model since the same relationship was observed in the simultaneous equation model which confirms the validity of the outcome.

The results, however contradicts the recent observation of Abokyi, Appiah-Konadu, Sikayena, and Oteng-Abayie (2018) about the manufacturing sector of Ghana. Abokyi, Appiah-Konadu, Sikayena, and Oteng-Abayie (2018) observed a negative relationship between electricity consumption and manufacturing value added in Ghana. It is possible to assume that the difference outcome only reflects the different sector as could be seen in the case of other studies on the service sector elsewhere. The results of Mawejje and Mawejje (2016) in Uganda only support the fact that a significant relationship exist between electricity consumption and service value added but could not resolve the issue of positive or negative relationship. Additional support could, however, be implied in the studies that used power crisis or outages. Simulation results by Ou, Huang and Yao (2016) indicated that the effects of electricity consumption on industrial outputs vary in different sectors.

The outcomes of the studies of Abeberese, Ackah and Asuming (2017), Arlet (2017), Abotsi (2016), Mensah (2016) and Odotei (2016) all lead to the conclusion that stable electricity power supply have positive impact of firm performance. Since stable supply simply imply more electricity consumption, the outcome of this study was considered a confirmation of the firm level relationship at the industrial sector level. Another departure from the outcome of this study was the observation of Peters, Sievert and Vance (2013) which observed no significant relationship between electricity usage and micro-enterprises performance in the then Brong-Ahafo region in Ghana. There are reasons why this observation may not necessarily contradict the outcome of this study which include, the use of micro-enterprises most of which are informal and uses less electricity according to World Bank Informal Sector survey on Ghana in 2013 which coincide with the period the work was done and the fact that the study population was in only one region while this study consider all regions in Ghana.

The second objective sought to examine the effects of electricity distributional losses on service value added in Ghana. The results found a direct significant effects of electricity distributional losses on service value added in Ghana. This finding contradicted the apriori expected sign but was interpreted to signify the possible evidence of illegal electricity connection or activities in the service sector which turns a loss to the electricity sector to a success story for the service industry.

The third objective aimed at identify the relationship between per capita electricity consumption and GDP per capita growth rate in Ghana. The outcome of the analysis indicated a negative relationship between per capita electricity consumption and GDP per capita growth rate in Ghana. Much as this observation was contrary to the expected effect of electricity consumption on economic growth; it was interpreted to reflecting the high cost of electricity in Ghana as well as the obvious fact that a greater percentage of the electricity in Ghana are consumed at the household rather than industrial level. Further probe revealed that the relationship is actually reciprocal since a simultaneous or bi-directional negative relations was observed between the two variables. That is, electricity consumption explain economic growth rate proxy by GDP per capita growth rate, while economic growth also explain electricity consumption in Ghana.

The results supported the Energy-led-Growth-led-Energy hypothesis assertions that there exists a bidirectional causality between electricity consumption and economic growth as in the study of Bayar and Özel (2014) on emerging economies. The outcome of the two models used also confirmed the position of Omri (2017) who explained that these mixed results can be attributed to the different data used, selected variables, and econometric approaches used for the analysis. That is, with the simultaneous equation model, this study could have supported the Energy-lead-Growth hypothesis by assuming that the direction of causality is only from electricity consumption to economic growth.

The fourth objective sought to identify the relationship between electricity transmission and distributional losses and GDP per capita growth rate in Ghana. The results indicated an expected negative relationship between electricity distributional losses and GDP per capita growth rate. The outcome suggested that increasing distributional losses is injurious to the economic growth in Ghana. The results confirmed the position of Best and Burke (2018) who also observed a negative effects of transmission and distributional losses on economic growth. The outcome, however, contradicts the observation of Adams, Klobodu and Lamptey (2017) in Ghana that transmission and distributional losses have no significant impact on economic growth. Elizalde and Jiménez (2013) also observed a positive relationship contrary to the negative relationship observed in this study.

It was also observed that increasing the percentage of electricity from hydro-power sources had positive effects on service value added but negative effects on the GDP per capita growth rate in Ghana. The negative effects on GDP per capita growth rate was expected since the reduction of hydro-electricity in Ghana are mostly responses to powered crisis and comes at a higher cost to the state.

Chapter Summary

The chapter presented, analysed and discussed the main findings of the study based on the stated objectives. The analysis provided enough information to address all the objectives with some interest findings some of which defy the apriori expectation but which were theoretically plausible.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This section presents a brief over view of the study after which the main findings were summarised in line with the stated objectives. The implications of the findings were given in the conclusion section after which recommendations were given based on the conclusion.

Summary of the Study

The purpose of the study was to examine the relationship among electricity consumption, distributional losses, service value added and GDP per capita growth rate in Ghana. The analysis of the study consider the effects of electricity from both industrial and national level using service value added and GDP per capita growth rate. The study used time series for the period of 1988 to 2018 on the economy of Ghana. The quantitative research approach was followed for the analysis which allows for series of hypothesis on the relationship among the variables to be tested. The Auto-Regressive Distributed Lag (ARDL) and SURE models were followed to test the various electricity consumption-economic growth hypotheses as explained in the literature review. The choice of the model was motivated by the results of unit root test which found that the variables were integrated of different orders but all are either I(0) or I(1) time series variables. It was possible for the ARDL bound testing co-integration procedure to produce consistent results when a mixed of series integrated of order zero and one are combined. The appropriate model adequacy test were performed and the best fit model was presented and interpreted. Both the short and long run models were estimated after the bound test co-integration result identified the existence of at least one co-integration equation among the variables. The results were presented and interpreted based on the following objectives:

1. To assess the relationship between electricity consumption and service value added in Ghana.
2. To examine the relationship between electricity distributional losses and service value added in Ghana
3. To analyse the relationship between electricity consumption and GDP per capita growth rate in Ghana.
4. To identify the relationship between electricity distributional losses on the GDP per capita growth rate in Ghana.

Summary of Main Findings

Based on the four objectives the following main findings were made as outline below.

The study found that per capita electricity consumption had direct effects on service value added in the service sector of Ghana. That is, increases in electricity consumption have the tendency to increases service value added in Ghana. The results again found a direct significant effect of electricity distributional losses on service value added in Ghana. Meaning, instead of being injurious to the service sector, electricity distributional losses are advantageous to the industry.

The results further indicated a negative simultaneous relationship between per capita electricity consumption and GDP per capita growth rate in Ghana. That is, electricity consumption and GDP per capital growth rate explain each other in the Ghanaian context. The results again observed an expected negative relationship between electricity distributional losses and GDP per capita growth rate. That is, reducing distribution losses could increase GDP per capita income of Ghana.

Conclusions

The findings of the study have several implications for the economy of Ghana. The observation that electricity consumption has direct effects on service value added was not surprising since electricity usage promote innovation by allowing for improve tools to be used. However, it also implies continuous power outages, which reduce electricity consumption, which could equally reduce the contribution of the service sector to GDP of Ghana. Electricity consumption indicated a negative effect on GDP per capita which could imply that utility charges may be eroding the gain from electricity consumption especially since service industry in Ghana are not noted for advanced technology. It could also imply the labour hours are relatively cheaper than machine hour when electricity is used to power machines to substitute labour.

The fact that distributional losses have positive effects on the service value added also points to the possibility of illegal connection since one major components of distributional losses is unpaid illegal power usage. This suggests that the fact against distributional losses may be difficult since a greater percentage may have been intentionally created to help industries outwit the system to the detriment of Ghana, and hence benefits from the losses. Distributional losses, however, indicated negative effects on GDP per capita which suggested that though the service sector benefits from the losses; the overall effects on the economy is negative. Hence, there is enough justification to seek to reduce distributional loses at all cost. To underpin, the macro benefits of reducing distributional loses shall be positive, even though a few negative micro effects can be observed.

Since increasing electricity consumption may imply increasing capital intensity, firms in the service sector of Ghana are recommended to increase their capital intensity. The ministry of Trade and Industry must also encourage firms in the service sector to increase their invested towards consuming more energy in order to boost GDP growth.

Recommendations

The following recommendations were offered based on the conclusion drawn. The Ministry of energy must ensure the necessary investment into the energy sector to ensure the supply of reliable electricity power industry while liaising with distribution companies and the Public Utility Regulatory Commission to ensured realistic price that will allow industries to grow. The Distribution companies must invest into modern technologies to reduce distributional loses since the overall effects of reducing distributional loses shall be positive on both industries and economic performance. The metering department of the distribution companies must ensure proper metering regulation and reduce the number of companies that are located in house who are using residential rate for commercial purposes.

Suggestions for Further Studies

The major limitation of the study was the level of aggregation in the data used which did not allow for the analysis to be done at the individual firm level. Future studies need to focus on the relationship between electricity consumption and firm level productivity or performance for a disaggregated results. Also, the analysis could be expanded to include the manufacturing subsector of Ghana.

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