DETERMINANTS OF ELECTRICITY GENERATION: THE CASE OF SELECTED SUB-SAHARAN AFRICAN COUNTRIES.

BY

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DECLARATION

This is to certify that this thesis is the result of research undertaken by Dorcas Asaah Peprah towards the award of the Master of Philosophy (MPhil) degree in Economics at the Department of Economics, University of Ghana.

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ABSTRACT

The World Bank Reported in 2013 that 25 out of the 48 SSA countries were experiencing energy crises which has resulted in brownouts and blackouts in those countries. Consequently, many sectors of the economy of these countries have being suffering great losses as they experience incessant power outages. Therefore the study focused on the factors that determine the generation of electricity in the case of selected SSA countries so as contribute in the curbing of the situation. Also, as a result of the harmful effect of the generation of electricity from non-renewable sources, the study investigated the relationship between the renewable and non-renewable sources of electricity generation so as to verify whether the renewable source of electricity generation can be a substitute for the non-renewable or they are actually complements.

Based on the Hausman test, the fixed effects model was found to be superior to the random effects model for the study. However, due to the presence of serial correlation and heteroscedasticity in the data used, the robust standard error was used to correct these two problems in the fixed effects model. The results of the fixed effects model showed that privatisation has a strong positive effect on electricity generation. Also labour and GDP per capita have a statistically significant effect on electricity which is also positive. However, the regulatory quality variable has an insignificant effect on electricity generation. Additionally, the study found out that hydroelectric power generation which is a renewable source and electricity generation from non-renewables such as the three fossil fuels (coal, oil and gas) are substitutes. Also,

privatisation was found to have a negative relationship with non-renewable power generation.

The policy recommendation for the study is that privatisation in the generation of electricity should be encouraged in the selected SSA countries since it can essentially lead to an increase in the production of electricity. Also, since hydro source of power generation can be substituted for its alternative, measures should be put in place to generate more electricity from a hydro source which is environmentally friendly as compared to the production of electricity from a non-renewable source.

DEDICATION

I dedicate this work to God who has been my source of help throughout my academic life.

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I want to acknowledge the Lord God Almighty for His divine presence that has been my source of encouragement from day one to the completion of this thesis. I also appreciate my supervisors, Dr Eric Osei–Assibey and Dr Louis Boakye-Yiadom for their commitment to this work. I am very grateful to them for their contributions made. A heartfelt thanks to my parents, Mr and Mrs Oppong Peprah and my all siblings for their encouragement and support throughout my period of study.

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LIST OF ABBREVIATIONS

FGLS	Feasible Generalised Least Square
GDPPC	Gross Domestic Product Per Capita
IEA	International Energy Agency
Kwh	Kilowatts per hour
OLS	Ordinary Least Square
SSA	Sub-Saharan Africa
WDI	World Development Indicator
WGI	Worldwide Governance Indicator

CHAPTER ONE

INTRODUCTION

1.1 Background

Electricity plays a very important role in an economy as a whole and also in the lives of individuals in every nation. The availability of electricity opens the economy to a lot of opportunities: on the contrary, the shortage of electricity in an economy creates an unfavourable environment for growth in such a country. A consistent flow of electricity is therefore beneficial to every economy.

Although the Millennium Development Goals (MDG) did not have availability of electricity explicitly indicated as a goal, electricity availability is considered crucial for the economic, environmental and developmental concerns facing the world. The poor in developing countries would have the opportunity to engage in better income generating activities when there is a reliable supply of electricity. Such opportunities will ultimately lead to the improvement in the standard of living of the poor. Therefore, poverty alleviation which is one of the very important targets of the Millennium Development Goals can easily be achieved when there is the availability of electricity.

Moreover, the society also stands to gain from a continuous flow of electricity particularly during the dark of the night. The light produced by electricity aids in the easy movement of people and things in a society, especially during the evenings when the sun does not provide light which helps prevent accidents and injury. Additionally, it also provides a level of security and safety to the public. The act of arm robbery, stealing, murder and other dangerous deeds which normally occur during the nights are minimised when electricity is used to produce light. In short, electricity is very needful in every society because of the benefit of safety and easy mobility especially in the dark part of the day (Power Africa Annual Report, 2014).

Also, firms and enterprises benefit from a regular flow of power in several ways. A consistent electricity supply gives entrepreneurs the opportunity to use equipment with ease since most of the modern equipment requires electricity in its operations. Aside this benefit, communication is a very important tool in business and electricity is known as a facilitator of communication. For instance, cell phones which are the most portable tool for communication for most entrepreneurs need electricity for the charging of its battery before it can function. In times of power shortages and rationing, entrepreneurs resort to the use of diesel generators for its operations which are more expensive as compared to the electricity from the national grid. Consequently, leading to increment in cost of production and reducing efficiency as well (Mayeh-Tasch et al., 2013). Hence the role that a constant flow of electricity from the national grid plays in business cannot be overemphasised.

Further, the sectors of the economy such as the health sector and the education sector also benefit from a consistent flow of electricity. Education, which is very essential in the development of a country is highly affected by irregular flow of power. Students as well as teachers need electricity to light up their bulbs for academic work. Teachers use light to study and prepare their lesson notes whilst students also use light to study, especially in the evenings. Unavailable electricity limits students and teachers to a few hours of studies in a day. This is because, they can only actively engage in academic activities during the day time but may virtually be unproductive when there is no electricity to light up their bulbs for studies in the evenings. This can have an adverse effect on the human capital in a country since education is one of the very fundamental ways of building up a nation's human capital. Likewise, the health sector makes use of electricity in so many ways. It plays an essential role in the operations of the hospitals, and other health centres. Electricity is used to power fridges in hospital in order to store some medicines that may need such lower temperatures for preservations. Also, pharmacies uses electricity to power air conditions to store drugs properly and blackout in the surgery room poses a threat to the life of any patient who may be undergoing a surgery. Therefore, available electricity is essential in both the health sector and education sector (Power Africa Annual Report, 2014).

Adequate supply of electricity plays a vital role in every economy. There are several factors that affect the supply and reliability of electricity among which the amount of electricity generated is expected to be key. The level of electricity generated in a country affects the amount of electricity supplied in a country. This is because electricity cannot be stored and therefore the amount of electricity supplied is more or less the same as the amount of electricity generated.

However, the electricity industry in sub-Sahara Africa is faced with a lot of challenges which has affected the electricity generated in the region. The power sector's infrastructure in Africa suffers a deficit and that it is the least developed in the world (Herfindahl and Treat, 2009). The power infrastructure in sub-Saharan Africa has not been well developed to make use of the available energy resources to satisfy the power needs of the countries in the region (Herfindahl and Treat, 2009). Also, majority of the available infrastructures which were installed before the 90's are hardly maintained; consequently, reducing the ability of the infrastructures to be more efficient. Hence, the services provided by the available electricity infrastructure in the continent is only a proportion of the services provided by the power infrastructure in most developed countries. The economy of most SSA countries have suffered detrimental lost as a result of the poor underdeveloped infrastructure in the region (IEA, 2014)

By international standards, most of the facilities in SSA countries generate electricity on a small scale. Consequently, most SSA countries do not benefit from economies of scale in the area of electricity generation. Producing electricity on a small scale leads to high cost of electricity generation which may result in a high electricity cost per kilowatt hour (Kwh). The high power cost will definitely cause an increase in production cost of goods and services which would eventually contribute to an increase in the prices of goods and services produced in the economy and consequently result in inflation. However, the facility could sell power at a lower price if electricity was generated on large scales. Furthermore, high electric power cost can be a disincentive to investors. The tire factory in Nigeria and the textile factory in South Africa closed their facilities because of unreliable and costly electricity (Herfindahl and Treat, 2009).

Furthermore, SSA produces electricity at a very low level as compared to other regions. The amount of power generated a country generates depends on the installed generation capacity of that country. The installed generation capacity in the SSA is very low. It was reported in a World Bank's (2013) study that the region's (SSA) total installed generating capacity is only 28 Gigawatts which is equivalent to the total generation capacity of a country like Argentina (World Bank, 2013). Consequently, the World Bank noted that, the amount of power generated in SSA is almost the same as the amount of power generated by Spain which is less populated (World Bank, 2013). This depicts that the amount of electricity produced in the region (SSA) is relatively low when compared to other regions.

1.2 Problem Statement

Energy resources are available and are even more than enough to meet the increasing demand for electricity on the continent. Sub-Saharan Africa is rich in energy resources but poor in generation. The International Energy Agency (IEA) reported in 2014 that nearly 30% of the world's discoveries of gas as well as global oil were found in SSA. Aside this, there exist several renewable resources yet to be tapped such as the available solar energy source which has not been well exploited. Additionally, the region has a high hydro and wind potential source of power generation especially around the coast and geothermal in the East African Rift Valley (IEA 2014). Sub-Saharan Africa is well endowed with energy sources, however, the electricity generated in SSA is low when compared to that of other regions hence the level of consumption is equally low.

Further, as a result of the electricity infrastructure which is not well developed and well maintained as well as low installed electricity generation capacities in SSA, the amount of electricity generated in the region is very low. Hence these problems pose a major challenge to the consistency and reliability of electricity supply in the region. It is sad to know that only 24 percent of the total population of the region have access to electricity. Also, 25 out of the 48 SSA countries were going through energy crises which has resulted in brownouts and blackouts in those countries. Additionally, the manufacturing enterprises have been suffering great losses since they experience power outages on an average of 56 days in a year (World Bank, 2013). This has adversely affected the economies of the countries in SSA.

Given poor reliability of electricity, maintaining production plans by firms has been very frustrating. The uncertainties associated with production schedules can lead to the loss of perishable raw materials needed for production. Also, impromptu blackouts associated with electricity supply in the region has also led to the adoption of costly diesel generators which increases the production cost of these firms. Studies have ascertain that, energy cost could reduce by 60% or even more if firms were connected to a more reliable electricity grid instead of relying on on-site diesel generators. Herfindahl and Treat (2009) reported that, tropical fruit producers in Ghana could have experienced a decline in energy cost by 60 percent if they have had access to a reliable electricity grid instead of using more expensive diesel generators. Also, apparel exporters in Kenya reported that, power generated by on-site diesel generators is 20 percent more costly as compared to electricity power from the grid. Therefore, production in the sub-region has been adversely affected due to the existence of uncertainties associated with electricity supply.

After independence, public utilities were state-owned therefore, the state controlled the operations of such facilities. So, tariffs paid by users of public amenities were heavily subsidised because of political interest. Also, regulations, especially those that concerned labour in the industry were politically driven so as to make the ruling party more popular. However, the donors started pushing for a reformation in the public utilities in SSA in the 80's because of the contraction of the budget coupled with debt crises. In the 90's, the donors were demanding a full privatisation of the public utilities in most SSA countries (Bayliss and Mckinley, 2007). Initially, the business conditions in SSA were not conducive therefore it was a disincentive to private investors. However, African leaders restructured the system in order to attract private investors when they recognised the need for privatisation. As a result, more private investors have recently responded by investing in the public utilities in SSA especially in the electricity sector (Power Africa Annual Report, 2014).

One of the problems of Sub-Sahara Africa in the production of electricity is due to the fact that electricity produced in most SSA countries usually rely on only one source of power generation. Most SSA countries over rely on the use of either any of the fossil fuel (coal, oil, gas) or hydro sources of electricity generation without diversifying. Although coal plays a very important role in the production of electricity in SSA, most SSA countries are reducing the share of coal and oil energy sources in the production of electricity. The countries are rather shifting to the use of a more sustainable means of generating electricity such as renewable source of power generation. The cost of producing electricity from these renewables is falling therefore making the use of such resources for power generation more feasible (Deloitte, 2015). It was forecasted that “by 2022, non-hydro renewables are expected to increase their share in the energy mix by a factor of five from 2011 values” (Deloitte, 2015). Likewise hydro is also estimated to double in output because of the hydro potential in the region by 2022 (Deloitte, 2015). Therefore, the renewable source of power generation may replace the non-renewable source of generation in SSA in the near future.

It is very unfortunate to realise how most countries in SSA are highly endowed with resources for generating electricity but the region continues to experience intermittent power supply. Little empirical research has been done to investigate into the key factors that influence the generation of electricity in SSA. Therefore, empirical results from this study would inform policy makers in their decisions in the area of electricity supply and generation. This research is therefore aimed at estimating the factors that determine electricity generation in SSA.

1.3 Research Questions

Therefore three basic questions motivate this study:

- How privatisation of the electricity industry does affect electricity generation in SSA?
- How does regulations quality affect electricity generation in SSA?
- What is the relationship between renewable and non-renewable sources of electricity generation in SSA?

1.3 Objectives of the Study

The main objective of the study is to investigate the factors that drive electricity generation in SSA.

The specific objectives are to:

- Investigate the effect of privatisation on electricity generation in SSA.
- Investigate the effect of regulations on electricity generation in SSA.
- Investigate whether non-renewables (coal, oil and gas) substitute or complement renewables such hydro in the generation of electricity in SSA.

1.4 Justification of the Study.

The energy demand in sub-Saharan Africa has seen much growth although it accounts for only 4% of the world energy demand. The energy demand grew by 45% in SSA from 2000 to 2012 (International Energy Agency, 2014). Although there has been growth in the demand of energy in sub-Saharan Africa, there exist shortage in electricity. A vast majority of about 620 million people or two-thirds of the population do not have access to electricity as a result of shortages in the supply of electricity. 'For those who do have electricity access in SSA, average residential electricity consumption per capita is equivalent to around half the average level of China or one-fifth of Europe' (IEA, 2014). The electricity generated in SSA is not enough to meet the needs of the few who may already have access.

Further, with the high rate of population growth, it is expected that, the situation may worsen in the near future. It has been projected by the International Energy Agency that, the size of the economy of SSA will quadruple in 2040. Additionally, the

International Energy Agency forecasted that the population will more or less double to 1.75 billion and the demand for energy will go up by 80 percent in 2040 (IEA, 2014). This projections insinuate that a huge expected amount of electricity will be needed to fuel economic activities in future. Also, the growth in the population may eventually lead to an increase in the demand of electricity. Therefore, it is essential to put in place measures that will aid in the generation of the required electricity when the need be.

The problem of shortage of electricity may persist if conscious efforts are not made to curb the situation. The problem of accessibility of electricity may become worse in future if nothing is done to increase the amount of electricity generated because of the high rate of population growth in the SSA. In solving the problem of shortage, a better understanding of the factors that affect electricity generation is needed to aid in the increment of the amount of electricity supplied. To meet up with the present and projected demand of electricity there is the need to determine the factors that may lead to an increase in the generation of electricity. Accordingly, this research investigates the determinants of electricity generation in SSA so as to empirically discover realistic measures that should be undertaken to increase the generation of electricity in SSA.

Furthermore, many studies in the area of energy focused on the causality between electricity consumption and economic growth either for a group of countries or for a single country with little attention given to the generation of electricity. Although there are studies that focused on electricity generation, these studies used electricity generation as a proxy for electricity consumption and investigated into the causal relationship between electricity generation and economic growth especially in developing countries. However, the intensity of the effect of other factors that determine electricity generation has been seldom investigated in SSA. Little research has been conducted for SSA in this area hence this study fills this gab in literature.

1.5 Organization of the Study.

The remainder of this study is organized as follows: Chapter two provides an overview of the electricity sector of SSA. Chapter three also provides a review of both theoretical and empirical studies made on the subject matter. Chapter four will proceed to develop the model and methodology needed for the estimations in the study. Chapter five will then carry out the empirical analysis. The study will finally conclude with chapter six which will provide a summary and offer policy recommendations.

CHAPTER TWO

OVERVIEW OF THE ELECTRICITY SECTOR IN SUB-SAHARAN AFRICA

2.1 Introduction

This chapter presents an overview of the electricity sector in SSA. However, the chapter touches on the four main sources of generating electricity in SSA, the total installed capacities of the four main sources, the amount of electricity generated from them and the trend in electricity generation in SSA, especially, in fourteen countries under study. It also presents the accessibility rate and consumption rate of electricity in SSA.

2.2 Electricity Generation.

2.2.1 Source of electricity generation

Presently, the rapid rise in electricity use has driven the need to increase the amount of electricity generated since electricity is very essential in our modern society. Accordingly, globally, various sources of electricity have been exploited so as to meet the rising demand of electricity. Some of the options used as a sources of electricity generation are biomass, coal, geothermal, hydro, nuclear, oil, wind, natural gas, solar, among others. These range of options for the generation of electricity are used to meet the demand of electricity in different countries depending on the resource which is available.

As it was emphatically stated in chapter 1, there is enough resources for the generation of electricity in SSA, especially the renewables but haven't been well exploited to meet the present and future electricity needs of most of the SSA countries (IEA, 2014). As at 2008, an economically feasible hydropower potential of which was estimated to be 937 TWh, thus, approximately a tenth of the world's total hydropower potential situated in the region has not been exploited. Also, the natural gas reserves is about 5.2 trillion cubic feet with much of it being concentrated in Nigeria. Aside Nigeria, substantial natural gas reserves have also been discovered in South Africa, Mozambique, Namibia and Angola. Additionally, for the past six years SSA accounts for 30% of the oil and gas discoveries made in the world. Oil reserves have been discovered in Nigeria (36 billion barrels), Angola (9 billion barrels), and Sudan (6.4 billion barrels). Some other countries in SSA like Ghana among others have smaller reserves of oil deposits (Eberhard et al., 2008). Whereas some countries are endowed with enough resources for electricity generation, others are landlocked with limited resource for electricity generation.

Most of the countries in Africa generate electricity from the three fossil fuels: coal, oil, natural gas and one renewable energy source: hydro, whereas other renewable resources like solar, wind among others are not well exploited. Short notes on the four main source of electricity production in SSA is given below.

- ***Coal:***

Coal is one of the popular fossil fuel used for electricity generation. The coal after it has been mined is grinded into powdery form. This is done to allow for quick burning of the coal so that much heat can be produced and also to reduce the amount of waste. Then turbines convert the heat energy to mechanical energy and finally to electrical energy. Although coal is the cheapest among all the fossil fuels, it is also the dirtiest. The disadvantage with the production of electricity from coal is the high level of pollution into the environment. Coal as a source of electricity generation plays a very important role in the production of electricity globally.

- ***Oil:***

Another non-renewable source of electricity generation is oil. The chemical energy present in oil is converted to electrical energy by oil power plants then the electricity is distributed for use. This process involves the burning of oil which emits a very high level of pollution in the form of nitrogen and sulphur dioxide and other harmful particulates which has the potential of damaging the environment.

- ***Natural gas:***

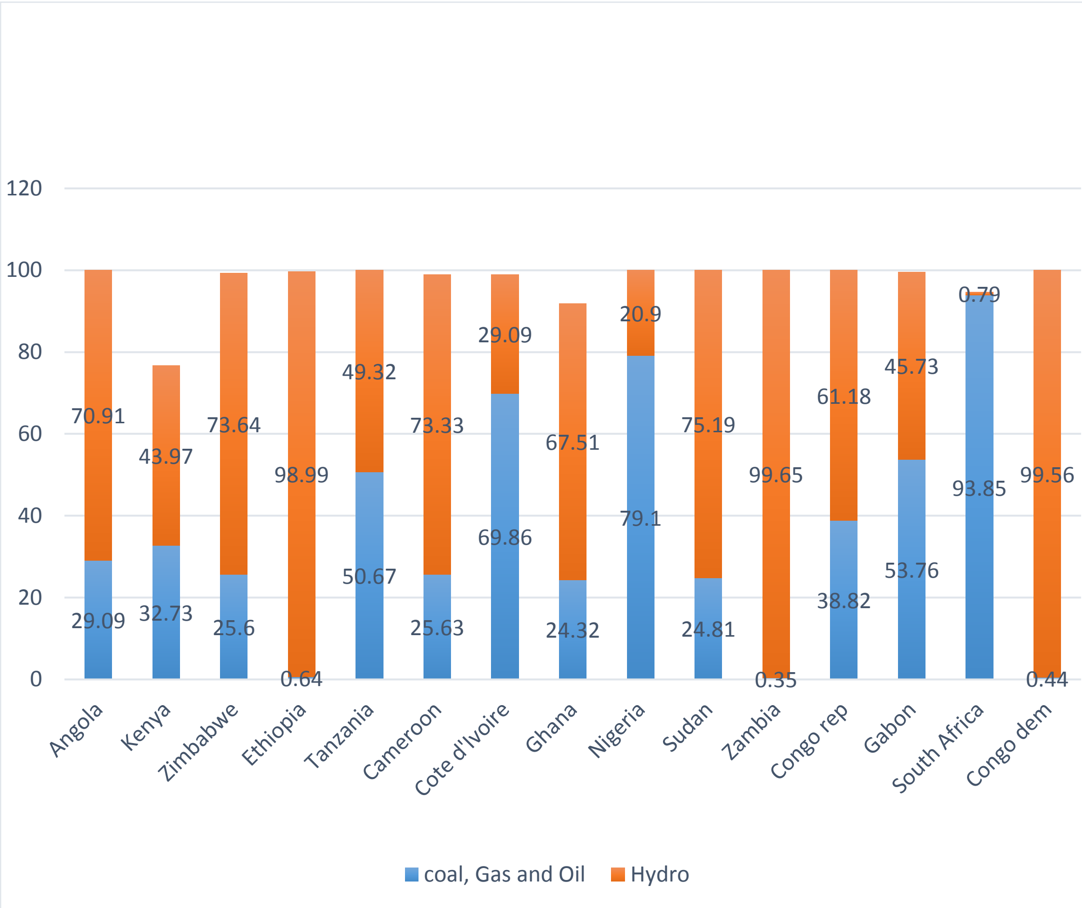
Natural gas is one of the cleanest non-renewables energy source used for the generation of electricity. Coal and nuclear power plants were initially chosen over natural gas, however, natural gas power plants have become one of the most popular sources of electricity generation due to technological changes, environmental factors as well as economic factors. The process of generation of electricity from natural gas starts with the extraction of the natural gas from the environment then the gas is treated and transported to the power plants where boilers and turbines burn the natural gas to generate electricity.

- ***Hydro:***

Hydro is the most common renewable source of electricity generation in sub-Saharan Africa. The hydro plants produce electricity by using dams. Water from a big reservoir is placed behind a dam and electricity is produced by allowing water from the dam to flow through the turbines. However, aside the fact that hydro power plants produce a very low greenhouse effect, the cost of production is very high as compared to other forms of electricity generation.

Below is a graph showing the percentage share of electricity from the four sources

Figure 2. 1 Share of the sources of electricity generation in the 15 SSA countries



Source: constructed from WDI, 2015.

Currently, every country in SSA has its own varying combination of fossil fuels and hydro in electricity generation. As aforementioned, most of these selected countries in SSA essentially generate electricity by using these three fossil fuel: coal, gas, oil as well as hydro. Examining figure **2.1,** almost all the other countries have more or less a hundred percent of the electricity generated from these four sources.

Whereas some countries have a high percentage of their power generation from the three fossil fuels, others also have a high percentage of their electricity generation from a hydro source. From **figure 2.1,** countries like South Africa, Tanzania, Cote d'Ivoire, Nigeria, and Gabon have more than half of their electricity generation from the three fossil fuels source. South Africa has the highest percentage of 93.85% of its electricity generated from fossil fuel. This can be due to the fact that South Africa is rich in the endowment of fossil fuel especially coal. South Africa is then followed by Nigeria with a share of 79.10% of her electricity generation from a fossil fuel source. The rest of the countries understudy have less than 50% of their electricity generation from the three fossil duels (coal, gas and oil). Zambia has the lowest percentage share of fossil fuel power generation. Zambia generate only 0.35% from coal, oil and gas followed by Democratic republic of Congo with as low as 0.44% of electricity generation from coal, oil and gas sources (**see figure 2.1)**

The generation of electricity from a hydro source is more popular in these SSA countries. All the selected countries in this study have a percentage of electricity production from coal oil and gas sources, however most of the countries have a high percentage share of electricity generation from a hydro source. Ten out of the fifteen countries understudy have more than 50% share of their electricity generation from hydro. A country like Zambia and DR Congo although has the least percentage share of generation from the fossil fuel, they generates 99.65% and 99.56% of electricity from a hydro source respectively. Likewise, Ethiopia has 98.99% of its electricity generation from a hydro. The country with the least percentage share of hydropower source is South Africa with a share of 0.79%. Then South Africa is followed by Nigeria. It can be said that, most of the countries understudy have a significant amount of electricity generation from hydro (**see figure 2.1**). Averagely, 36.64% of electricity generated in the fifteen countries under study is from coal oil and gas whereas 60.65% is from hydro source. This shows that the amount of electricity produced from hydropower is very high in these sub-Saharan countries than any other source. Even though electricity generation from hydro source is very high for these 15 SSA countries, there still exist unexploited hydropower sources of electricity generation in SSA likewise the other renewable sources of electricity generation like solar, wind, geothermal among others.

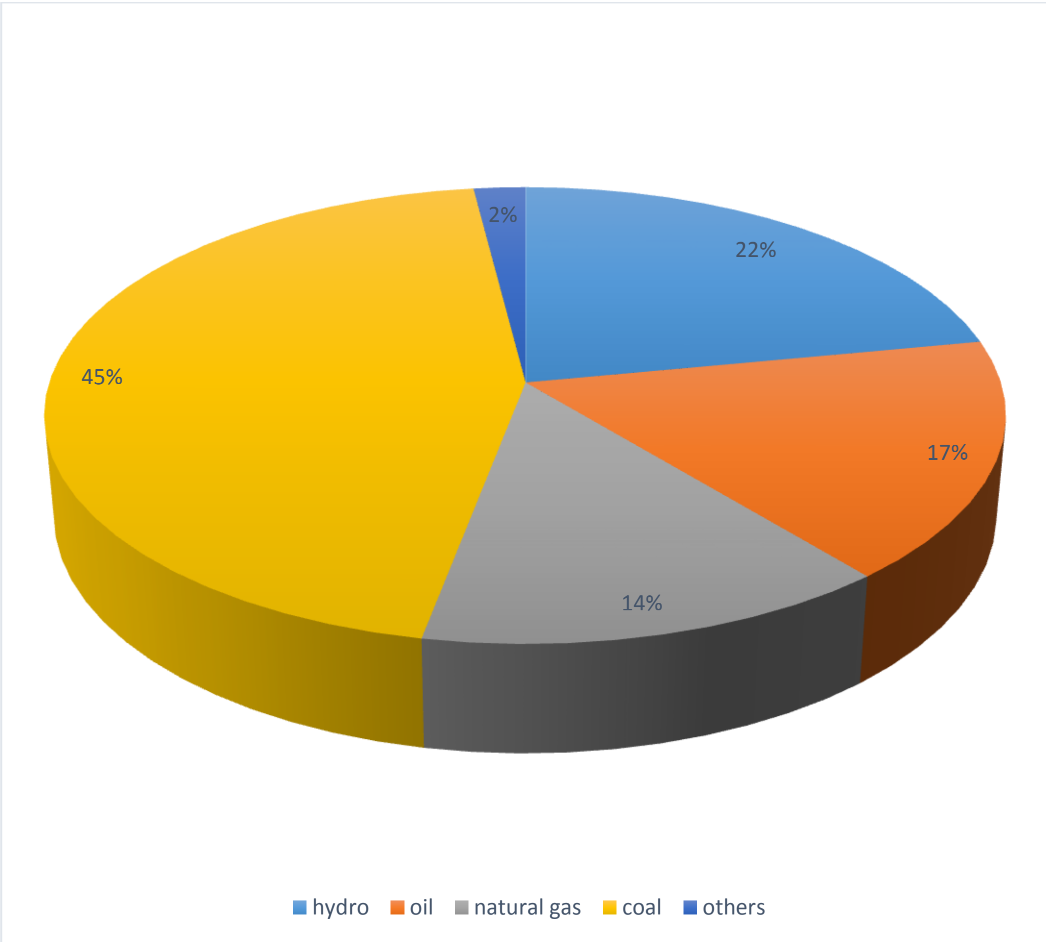
However, the reason for the variation in the proportion of the fossil fuel sources and hydro can be as a result of the resource endowment in these countries. Some countries may be rich in either coal, oil, gas or hydro, whereas others may not be that fortunate. A country like Nigeria and many others are very fortunate to have more than one of these resources available in their countries whereas other countries may not have these sources of electricity available in their countries. Therefore the countries who are rich in these resources have an upper hand in the generation of electricity over the others. In addition, some countries may have these sources available but may be constrained by factor such as capital for investments, ineffective governance and unconducive atmosphere for private investors among others.

2.2.2 Installed power generation capacity of these four natural resources in sub-Saharan Africa.

Some of the challenges the region faces is the low on-grid power generation capacity (African Development Bank Group, 2013). This problem goes a long way to affect the amount of electricity generated in SSA since a country cannot generate electricity beyond its installed capacity.

The installed generation capacity in SSA is one of the lowest in the world. With an installed capacity of 90 GW, when compared with other continents like Asia who has an installed capacity of about 2,192 GW as at 2012 it can be concluded that SSA's installed capacity is low (US Energy Information, 2015; IEA, 2014). Unfortunately, the installed capacity in SSA is unevenly spread. Some countries have a very high installed capacity whiles others have lower installed capacities. IEA in 2014 gave a report on the state of the installed capacity in sub-Saharan Africa. Per the IEA report, as at 2012, the on-grid power generation capacity in the region was just 90 GW but almost half of it was in South Africa. Also, 45% of the 90 GW installed generation capacity is from coal but a higher share of it is in South Africa. Likewise, Nigeria has the highest proportion of the total installed natural gas capacity, however, natural gas constitute just 14% of the total installed capacity in the region. Additionally, 22% of the installed capacity is hydropower generation capacity whereas 17% is oil power generation capacity. But the hydro and oil installed capacities unlike the coal and natural gas are more uniformly spread. Other renewables-based capacity excluding hydropower capacity is being developed although the base as at now is very low (IEA, 2014). The figure below shows the percentages of the total installed generation capacities of the sources of electricity generation in SSA.

Figure 2. 2 Installed generation capacities of the various sources of electricity generation in SSA



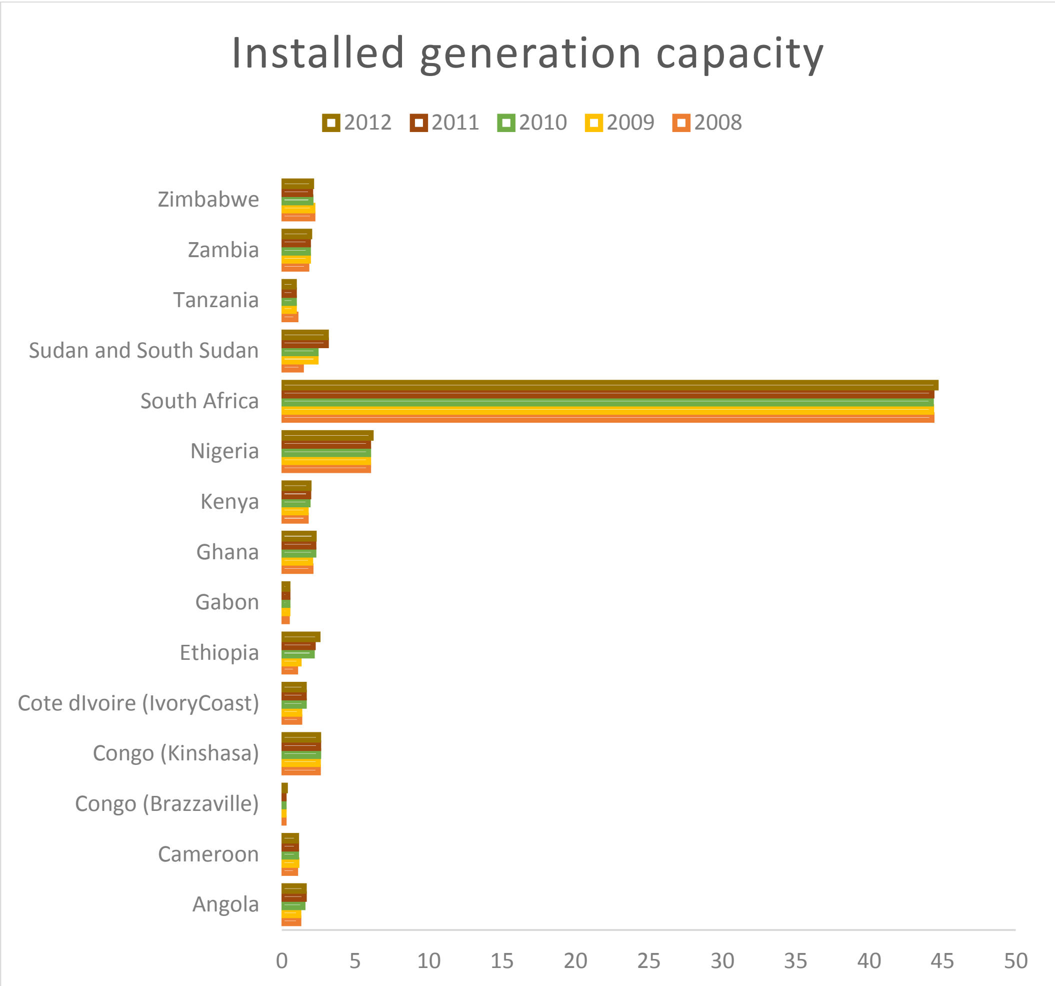
Source: International Energy Agency, 2014.

- ***Installed Generation capacity for the 15 SSA countries***

As mentioned above, the installed generation capacity for SSA is very low. The installed generation capacity is also not evenly spread but it is rather concentrated in some few countries such as South Africa, Nigeria and other few countries. From **fig**

2.3, the gap in the installed capacity among countries is made obvious. The figure shows how about half of the total installed capacity is concentrated in South Africa followed by Nigeria. The gap between the installed capacity in Nigeria and South Africa is even very wide. Looking at **figure 2.3,** it can be seen that most of the countries have not added any significant capacity to the already installed over the years. The low installed generating capacity in a way limits the ability to generate more electricity to make power available for accessibility.

Figure 2. 3 Installed Generation Capacity for 15 SSA countries



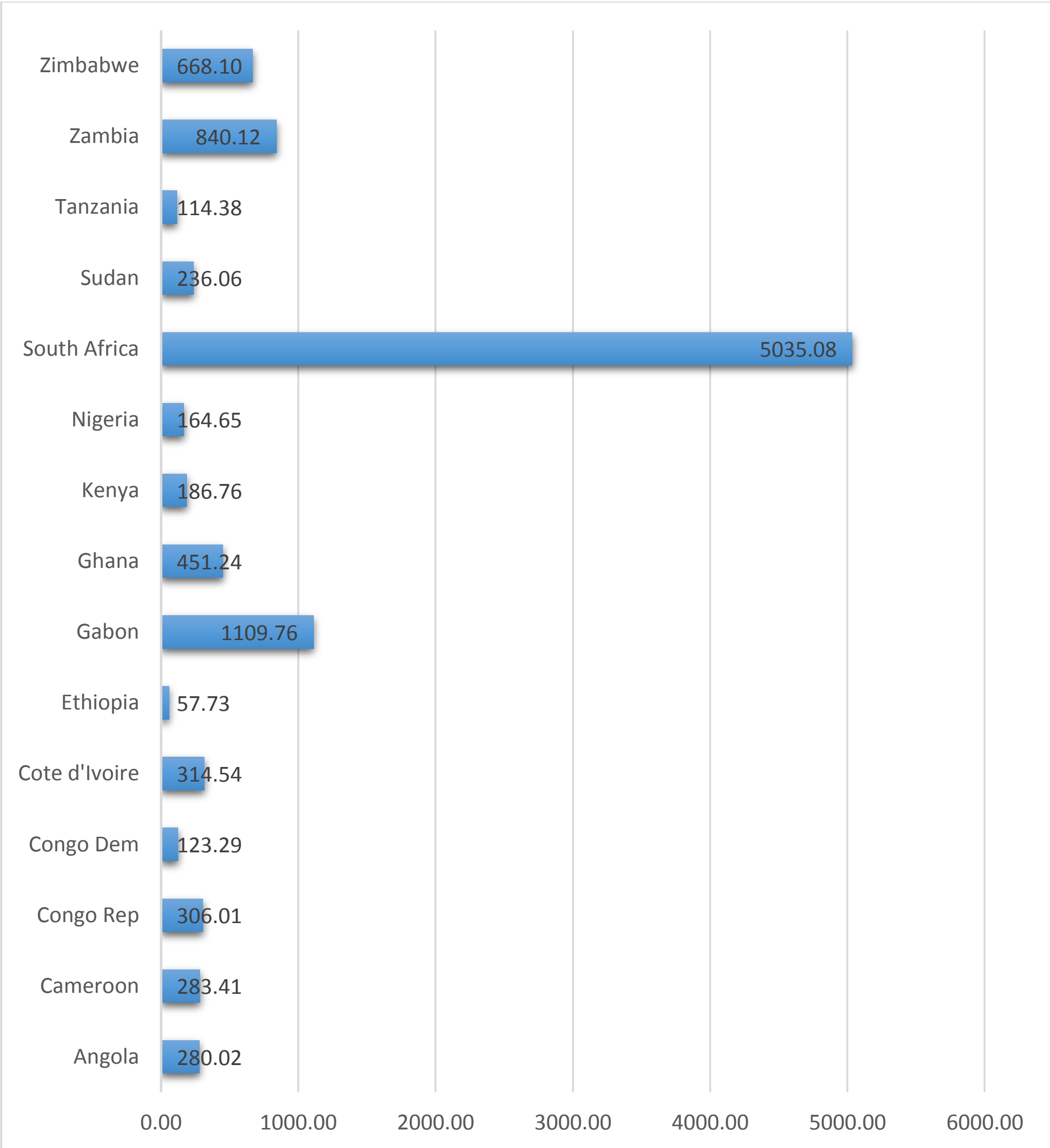
Source: Constructed from US Energy information, 2015

2.2.3 Electricity generation for the fifteen SSA countries

Africa's power sector is confronted with a lot of challenges. Aside the issue of low installed generation capacity being the main cause, other factors may also have great effect on the amount of electricity generated (Africa Development Bank Group, 2013). Although, some of the countries in SSA have enacted laws to curb the monopoly in the production, transmission and distribution of electricity, the sector is still characterised by monopoly from the stage of production to the final stage of distribution. Additionally, the electricity sector of Africa is still undeveloped with low infrastructure for generating electricity. The maintenance of power plants is even a problem because of lack of funds. Therefore, electricity generation is very low as compared to the rest of the world.

The production per capita of electricity is very low in these 15 SSA countries with the exception of some few: South Africa and Gabon when compared to other SSA countries. The electricity production per capita of South Africa which is known to be one of the largest economies in Africa is 5035.08. With a wide gab, Gabon which is the second highest country producer has a production per capita of 1109.76. The rest of the countries produce below 1000 kwh per capita with most of them within the range of 500 kwh per capita and 1000 kWh per capita which is below standard. The country with the lowest electricity production per capita is Ethiopia then followed by Tanzania. The amount of electricity Ethiopia produces is 57.73 kwh per capita and Tanzania is the second lowest producer of electricity among the 15 SSA countries with a production of 114.37 kwh per capita **(see figure 2.4**). The average electricity production per capita for these 15 countries is approximately 678.077 kWh per capita. This average amount of electricity generated is very low when compared to other parts of the world. The low electricity generation has affected the consumption of electricity. Therefore, it is not a surprise that the electricity consumption is also very low in SSA.

Figure 2. 4 Electricity production per capita for 15 SSA



Source: World Bank, 2015.

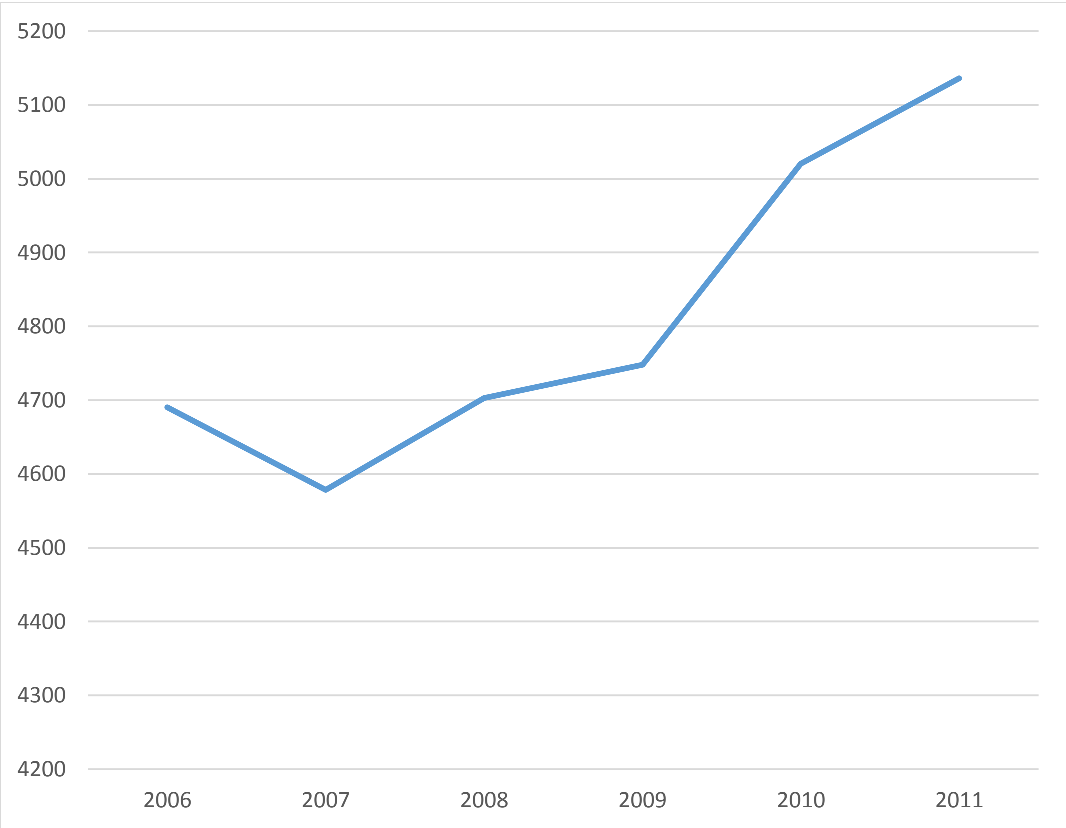
2.2.4 Trend in Electricity Generation

This sections looks at the trend in electricity generation in the 15 countries and also the trend in electricity generation without South Africa since South Africa seems to be more advanced in the generation of electricity than the rest of the countries understudy.

- ***Trend analysis without South Africa.***

The graphs below shows the trend in electricity generation in the 14 countries without South Africa.

Figure 2.5 Trends in Electricity production without SA (2006-2011)



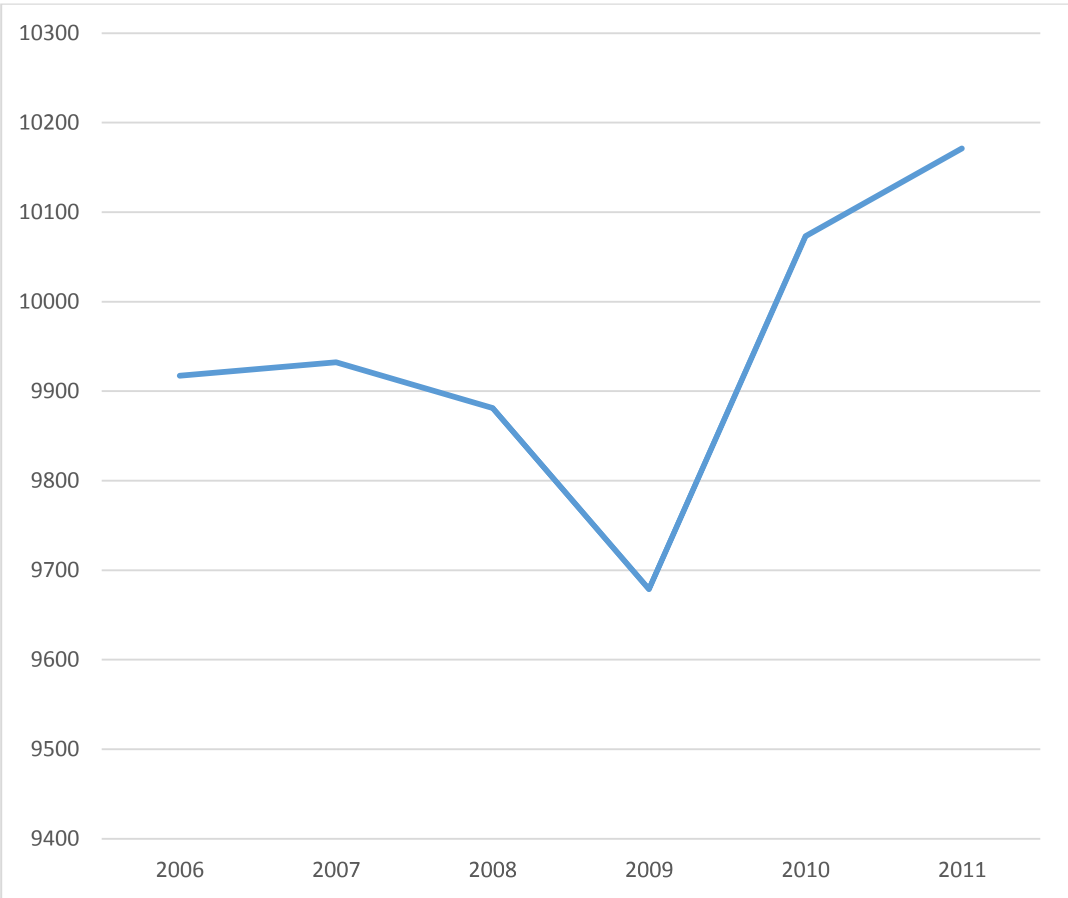
Source: constructed from World Bank Indicator, 2015

From **figure 2.5,** electricity generation per capita fell by 2.38% in 2007 then increased to a higher level at a growth rate of 2.72% in 2008. Electricity production per capita then increased again in 2009 but at a lower growth rate of 0.96% as compared to the previous year. Then in 2010, electricity generation per capita increased at a higher growth rate of 5.74% in the 14 countries. However, the growth rate was not sustained but fell to 2.30% in 2011.

- ***Trend analysis of electricity production with South Africa***

The graph below shows the trend of electricity production with South Africa.

Figure 2. 6 Trend in Electricity production with South Africa (2006-2011).



Source: constructed from World Bank Indicator

With the inclusion of South Africa, the trend in electricity production changed. After a growth of 0.76 in 2007, electricity generation per capita began to fall by 2.54 in 2008 then continued to fall in 2009 but at a very high rate of 10.08%. This was because of a fall in the generation per capita of electricity in South Africa in 2009. Electricity generation per capita then rose by a higher percentage of 19.64 in 2010. This was such a great improvement. However, the growth rate fell from 19.64% to 4.87% in 2011.

The growth rate of electricity generation per capita has not been increasing over time however, it seems to fluctuate with time. Some years experienced growth whiles some years experienced a fall in the growth in the rate of electricity generation. The growth rate increases in one year then falls in the next year. The most recent data, thus the 2011 data shows a fall in the growth rate of electricity generation. However, SSA has a very high population growth rate. Therefore, growth rate in electricity generation per capita should be stabilised to meet up the needs of the growing population.

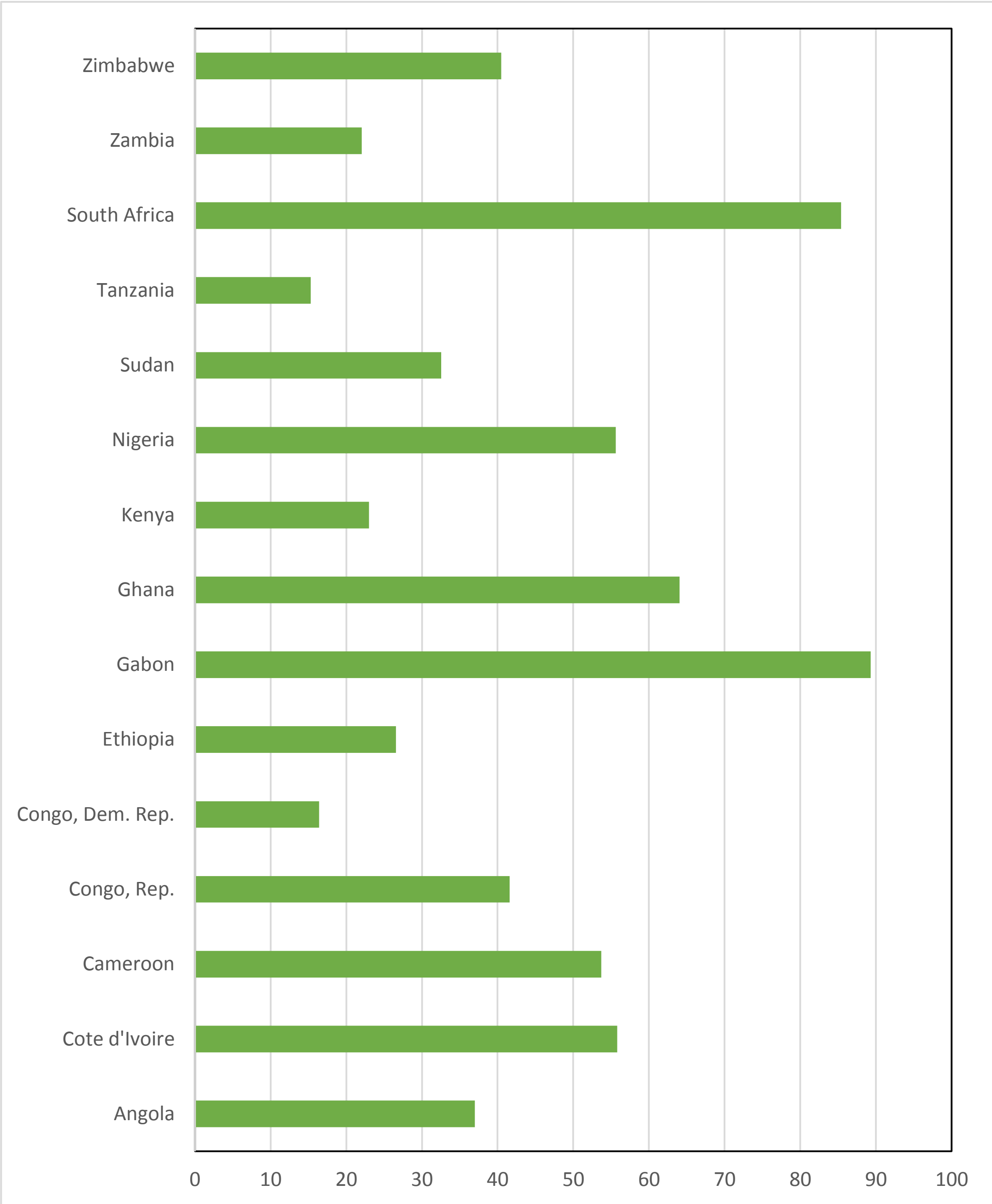
2.3 Accessibility of Electricity

The challenge in Sub-Sahara Africa in the area of electricity generation is that, the region lacks the ability to take advantage of the discoveries made in the resources to increase its electricity production. Therefore the region suffers from shortages and very low access to electricity

The International energy agency reported that globally, approximately 18% of the total population do not have access to electricity. This implies that about 1.3 billion people live without electricity in the world. Sadly, a high percentage of 97 of the world's population who do not have access to electricity happen to be located in either SSA or developing Asia (IEA, 2015). In SSA, only one-third of the population have access to electricity which shows that almost 620 million people in the region live without electricity (IEA, 2014). Currently, this problem in developing Asia is improving but it is rather worsening in SSA. The number of people without access to electricity in SSA have increased by 22 million as a result of the rapid population growth in SSA (IEA, 2014). Among the six countries characterised with a low accessibility rate, three happen to be SSA countries. These SSA countries are Nigeria, Ethiopia and Republic of Congo (IEA, 2015). Additionally, IEA reported that the six countries in Africa that are the focus of power investments have an approximate number of 240 million of their population living without access to electricity. These countries include Ethiopia, Ghana, Kenya, Liberia, Nigeria and Tanzania (IEA, 2015). This depicts how serious the problem of accessibility of electricity is in SSA.

The graph below shows the accessibility rate in the countries understudy.

Figure 2. 7 Accessibility rate of electricity for 15 SSA countries



Source: constructed from the World Bank, 2015

Examining **fig 2.7,** although some countries have a high percentage of their population having access to electricity, all the countries specified in the graph have a proportion of their population living without access to electricity. The situation is better in Gabon and South Africa. In Gabon and South Africa 89.3% and 85.4% of the population respectively have access to electricity. Both countries are highly endowed with resources such as coal, oil, natural gas, as well as hydro. These resources are primary natural source of generating electricity. Amidst these useful resources, Gabon with the highest accessibility rate still has a proportion of its population living without electricity. Gabon has a high accessibility rate in the urban centres but the accessibility of electricity in the rural centres is very low. This disparity in the accessibility due to location is common in most African countries. Additionally, Gabon still experiences black outs and frequent power shortages even with a high accessibility rate (AFDB, 2012).

Moreover, most of the countries indicated in **figure 2.7** have an accessibility rate being lower than expected. Averagely, only 43% of the population in these 15 SSA countries have access to electricity. This implies that approximately 57% of the population in these countries do not have access to electricity. The situation will be worse if South Africa is not included. Tanzania has the lowest percentage of 15.3 of her population with access to electricity. Tanzania was followed by the Democratic Republic of Congo with a very low access rate of 16.4%. From the **figure 2.7**, 9 out of the 15 SSA countries have more than 50% of the population living without access to electricity. The situation is quite better in the other 6 countries who have less than 50% of the population with no access to electricity. This depicts how seriously low the accessibility of electricity is in most SSA countries.

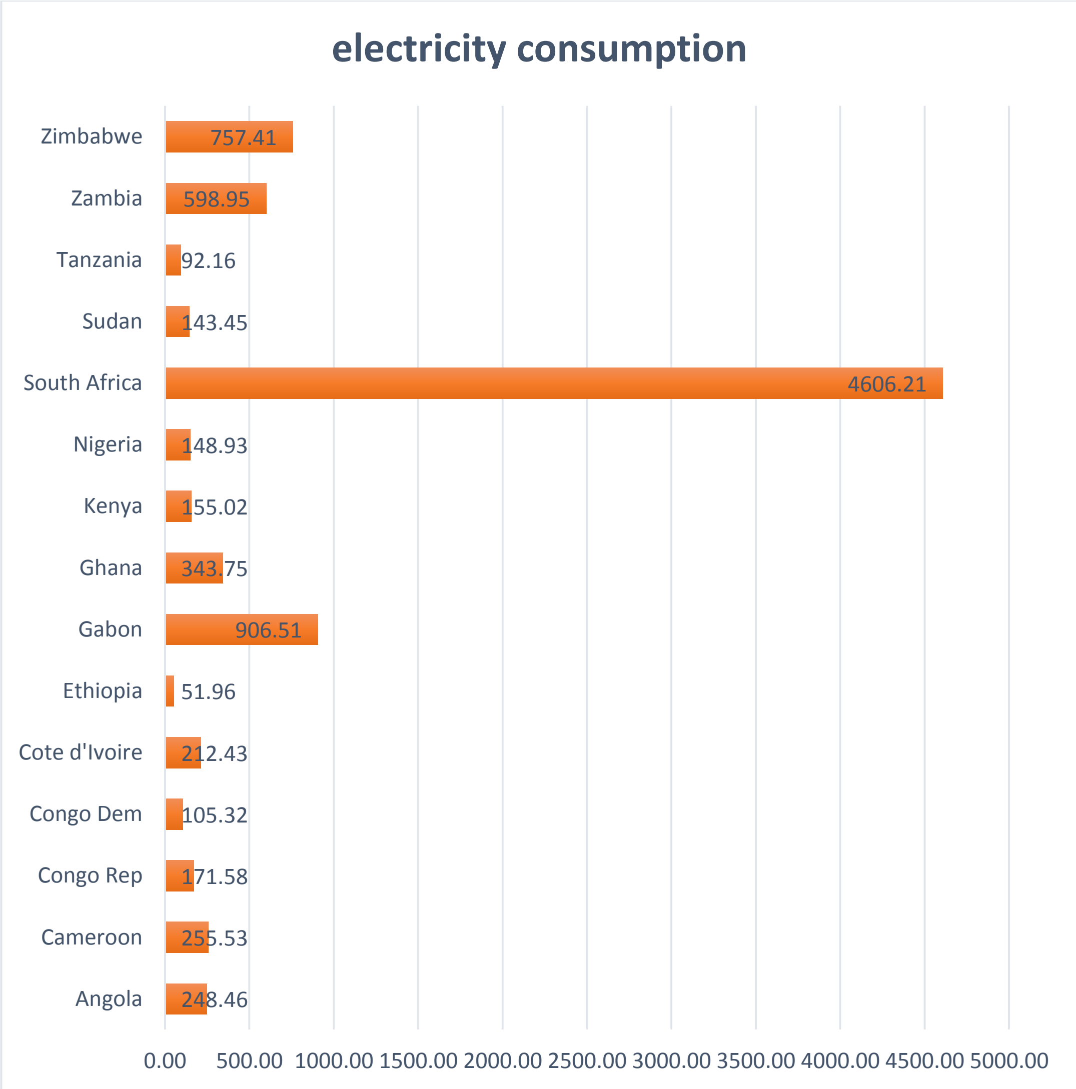
2.4 Electricity Consumption

The lower accessibility as a result of the lower supply of electricity has led to a low consumption of electricity in SSA (African Development Bank Group, 2013). The low accessibility rate of electricity shows that the consumption of electricity is also very low in SSA. The consumption of electricity is very instrumental in the development of an economy. A lower consumption of electricity affects economic activities. No wonder the economic status of SSA is one of the worse in the world.

With a low average electricity consumption per capita being 506.51 kWh, the electricity consumption per capita for these 15 countries range from 4606.21 to 51.96 kWh (see figure 2.2). The average consumption per capita falls to 366.86 when South Africa is excluded. Apart from South Africa, the other 14 countries have an electricity consumption below 1000kwh per capita. Among the selected countries, South Africa is the highest consumer of electricity with a per capita electricity consumption of 5035.08 kWh. This can be as a result of the size the economy since it is one of the largest in Africa however, the gap is very wide. South Africa was followed by Gabon with a per capita production of electricity of 906.51 kWh. The country with the least consumption is Ethiopia then followed by Tanzania. Ethiopia and Tanzania's electricity consumption per capita is 51.96 and 92.15 kWh respectively.

Below is a graph which shows the per capita electricity consumption in 15 SSA countries.

Figure 2. 8 Electricity consumption per capita in the 15 SSA countries.



Source: constructed from WDI, 2015

This level of electricity consumption in the 14 countries in figure 2.2 is very low when compared to South Africa which is also an SSA country. The amount of electricity consumed in the fourteen countries in SSA is very low and therefore the amount of electricity generated should be increased so as to increase the level of consumption of electricity.

Also, the International Energy Agency projections for 2040 forecast that, the size of the economy of sub-Saharan will quadruple by 2040 and the population will more or less double to 1.75 billion as well as an 80% increase in the demand for electricity (IEA, 2014). Therefore is the need to plan for the projected increment in future consumption.

Therefore the availability of electricity through the generation of a higher amount of electricity may solve the problems of shortages and low accessibility rate and have a positive effect on electricity consumption as well.

As a results of the upper hand South Africa seems to have in electricity generation when compared to the other fourteen countries, the study will not include South Africa in its estimations.

2.5 Conclusion.

The discussion above shows that the selected 14 African countries have a very low electricity generation. Although, there is growth, it fluctuates with time and is even falling. The accessibility rate as well as the generation per capita of electricity is very low when compared to other countries in the world or even other regions. Therefore, there is the need to increase the generation per capita of electricity in SSA.

CHAPTER THREE

REVIEW OF LITERATURE

3.1 Introduction

This chapter reviews relevant theoretical and empirical studies. It analyses the theoretical underpinnings of the study. The chapter also reviews empirical works which will serve as a guide in choosing the appropriate methodology and variables needed in assessing the factors that may give better explanations on the possible determinants of electricity generation.

3.2 Theoretical review

The theoretical review of this study is based on the theory of production. Before Adam Smith tackled the concept of production in his seminal 1776 book, several Greeks and Romans had also paid much attention to this concept. An example of such authors are Saint Augustine and Thomas Aquinas. Not forgetting Anne Robert Jacques Turgot who discovered one of the key characteristics of the production function, that is diminishing marginal returns (Gordon, 2011).

The theory of production is the first theory of the firm. Production involves the process of transforming factors of production such as capital, labour, raw materials and services into a good or a service (Wikipedia, 2015). The resources used to produce the finished product or good are called inputs whereas the amount of goods and services produced from these inputs are called outputs. Essentially, the theory of production in economics deals with the description of the production technology which explains the economic behaviour framework. There is an assumption that, producers at all times endeavour to produce the highest amount of goods and services at the lowest possible cost. This theory essentially tries to illuminate the reason behind the amount of resources employed and how much of these resources is needed to produce a given level of output.

The production theory uses the production function to explain the concept of the theory. 'It is generally believed that Philip Wicksteed (1894) was the first economist to algebraically formulate the relationship between output and inputs' (Mishra 2007). The production function is a mathematical representation of the relationship that exist between inputs and outputs. The function depicts the maximum amount of outputs that a firm is able to produce by using a specific sets of inputs with technology held constant. A production function is a heuristic device that describes the maximum output that can be produced from different combinations of inputs using a given technology. This can be expressed mathematically as a mapping $f : R_+^N \rightarrow R_+$ such that $Y = f(X)$, where X is a vector of factor inputs $(X_0, X_1, \cdots, X_n)$ and $f(X)$ is the maximum output that can be produced for a given set of inputs $X_i \in R+$. This formulation is quite general and can be applied at both microeconomic (i.e., individual firm) and macroeconomic (i.e., overall economy) levels. While production functions were originally designed with the individual firm in mind, macroeconomists came to realize that this methodology provides a useful tool for estimating certain parameters that cannot be directly measured from national accounts data. The most important of these is the elasticity of substitution between inputs such as capital and labour.

Elasticity of substitution in production is a measure of how easy it is to shift between factor inputs, typically labor and capital. This measure is defined as the percentage change in factor proportions resulting from a one-unit change in the marginal rate of technical substitution (MRTS). MRTS is the rate at which labor can be substituted for capital while holding output constant along an isoquant; that is, it is the slope of the isoquant at a given point. Thus, for a two-input production function, Y= f(K, L), the elasticity of substitution between capital and labor is given by

$$\sigma = \frac{\%\Delta\left(\frac{K}{L}\right)}{\&\Delta MRTS} = \left[\frac{d\left(\frac{K}{L}\right)}{dMRTS}\right] * \left[\frac{MRTS}{\left(\frac{K}{L}\right)}\right] = \frac{\partial \ln(K/L)}{\partial MRTS}$$

Where σ can be thought of as an index that measures the rate at which diminishing marginal returns set in as one factor is increased relative to the other (Nelson 1964). When σ is low, changes in the MRTS lead to small changes in factor proportions.

In the extreme case of fixed proportions or Leontief (1941) technology, the production function is represented as:

$$Y = \min(aK, bL)$$

where a, b > 0

The resulting isoquants for this production function are L-shaped and σ = 0. This implies that changes in the MRTS will not cause any changes in factor proportions, so output is maximized by producing in fixed ratios.

The other extreme is linear production technology:

$$Y = aK + bL$$

In a linear production function, capital and labor are perfect substitutes. The MRTS for this production function is infinity ($\sigma = \infty$) so the isoquants are straight lines.

The two most popular neoclassical production functions are the Cobb-Douglas and the CES. The Cobb-Douglas is a simple production function that is thought to provide a reasonable description of actual economies. It was created by labor economist Paul H. Douglas and mathematician Charles W. Cobb in an effort to fit Douglas's empirical results for production, employment, and capital stock in U.S. manufacturing into a simple function (Cobb and Douglas 1928). This functional form has been extremely popular among economists because of its ease of use and its

The Cobb-Douglas form,

$$Y = AK^{\alpha}L^{\alpha-1}$$

The MRTS of a cobb-Douglass production function lies between the two extremes, thus σ =1. This specification creates isoquants that are gently convex and easy to work with. Cobb-Douglas is a special case in a more general class of production functions with constant elasticity of substitution.

The standard constant elasticity of substitution introduced by by Arrow, Chenery, Minhas, and Solow (1961) is presented below:

$$Y = C[\alpha K^{\rho} + (1-\alpha)L^{\rho}]^{1/\rho}$$

Where C is a measure of technical progress and the coefficients α and $1-\alpha$ are distribution parameters between zero and 1 and can be used to determine factor shares. The substitution parameter is ρ where is defined as $\rho = \frac{\sigma-1}{\sigma}$. This formulation of the CES function has been criticized as being unduly restrictive because it assumes that technological progress has no effect on the marginal productivities of input factors.

One important feature of a production function is the law of diminishing marginal productivity. The law states that as more and more of an inputs is employed in production , the additions to the quantity of output is higher at the initial stages but a successive increment of the quantity of that particular input when used in production will result in a smaller increments in the amount of output produced. Most empirical works have labour and capital as inputs in their production function. Therefore the concept when applied to labour or capital states as more labour or capital is employed, the additions to output will eventually fall after sometime of successive additions of these inputs in the production process. Consequently, relationship between the inputs and outputs is expected to be nonlinear.

A production function can either represent the functional connection between the inputs and outputs of a single firm or of an industry/ sector/ economy level. The production function of the firm will focus on only the input and output of that single firm. Whiles, the aggregate production function represents the technical relationship between the inputs and outputs of numerous firms in which these firms employ different combinations of inputs to produce a similar product. Therefore, the production function of an industry/sector/economy is derived from the aggregate inputs used by various firms and the aggregate output produced by these different firms. This concept assumes that the total output produced in an industry, sector or economy depends on the inputs available. This suggest that the level of output is more or less determined by the inputs since the type and amount of inputs used in the production process determines the level of production. Mostly, at the economy level, the outputs are measured in terms of the Gross Domestic Product (GDP) and the output produced at the sector and industry level are measured by the aggregate outputs from the various firms in the industry or sector. The aggregate output is determined by factors such as physical capital, labour, human capital, knowledge, social infrastructure, amount of natural resources available in the economy among others. These factors that come into play to determine the amount of output to be produced are termed as inputs of the industry/sector/economy. Therefore the technical relationship that connects the inputs used in production and the output for an industry, sector or an economy is called the production function.

The aggregate production function underpins this study. This is because of the role the variables of interest play in determining the inputs used for production which eventually determines the output of the electricity generation industry.

3.3 Empirical review

The empirical literatures that investigated into the factors that affects electricity generation are reviewed in this section. At the macro level, some of the factors that may affects electricity generation may be social factors, economic factors, as well as institutional factors. This section reviews the empirical literatures of some of these factors.

3.3.1. Demand side factors

The factors that may affect the demand side of electricity have the tendency to affect the supply side of electricity. The growth in demand of electricity is one of the main factors that drives investment in electricity generation. (Anonymous, 2007). The fact that electricity when generated cannot be stored makes the connection between the demand and supply of electricity very stronger. Therefore the stakeholders of the supply of electricity may definitely consider the demand of electricity before producing a given amount of electricity to meet the available need. Consequently, the factors that affects the demand side of electricity are likely to indirectly affect the generation of electricity. Therefore literatures that relate the factors that may affect the demand of electricity to electricity consumption will be reviewed since these factors may indirectly affect electricity generation.

- ***Income***

Studies have found a relationship between electricity consumption and income. Ferguson et al. (2000) found a very strong correlation between electricity consumption and income for 100 countries in his study. This implies that there is a strong association between income and electricity consumption.

Kamaludin (2013) conducted a study on the electricity consumption in developing countries. His study adopted the Generalised Method of Moments and found that income affects the consumption of electricity positively. He postulated that this effect may be due to the increase in the demand for high technology appliances when income increases. His study used a panel data which covers the period of 1999- 2004 of 32 developing countries. Aside this study other studies in this area paid much attention to the causality between electricity consumption and income in some SSA countries. One of such study was conducted by Adom (2011), who researched into the electricity- economic growth nexus in Ghana by using the annual data of Ghana for the period, 1971 to 2008. He employed the Toda and Yomamoto's granger causality test and found a unidirectional relationship running from real GDP per capita to electricity consumption. His findings suggests a causality from income to electricity consumption in Ghana. This shows that the level of income affects electricity consumption in Ghana. Therefore if the level of income can affect the demand side of electricity then it may also affect the production of electricity.

There are other studies conducted outside Africa which rather investigated into the direct relationship between electricity generation and income and found income to impact electricity generation. Yoo and Kim (2005) used the granger causality test to probe the relationship between electricity generation and economic growth in Indonesia by using data from 1971 to 2002. Their study detected a causality running from income to electricity generation. A study consistent with that of Yoo and Kim (2005) is that of Lean and Symth (2010) who also investigated into the causality between economic growth and electricity generation. The study used data for the Malaysian economy covering the period from 1970 to 2008. The granger causality test employed showed that income affects the electricity generated in Malaysia. Also, a similar study used a time series data of the economy of Bangladesh from the year 1973 to the year 2006 and had this same finding of income causing the generation of electricity in Bangladesh. This study also adopted the granger causality test for its estimations (Sarker and Alam, 2010). The empirical studies above shows that demand truly affects the amount of electricity generated.

Gosh (2009) employed the annual data of India covering the period of 1970-71 to 2005-06 to investigate the causality between electricity supply and economic growth. The autoregressive bound testing cointegration test indicated a long run equilibrium relationship among the variables used in the study, thus: employment, electricity supply and GDP. However, the causality test showed no causal relationship between electricity supply and income in the long run but the test indicated a causality running from income to electricity supply in the short run. This implies that the level of income affects the supply of electricity in the short run in India.

- ***Population***

The population of a country may be a major factor in determining the amount of electricity consumed in that particular country which may also determine the amount of electricity produced. Studies in some African countries have confirmed this postulated relationship between population and electricity consumption. A study conducted by Ubani (2013) examined the dynamins of electricity consumption in Nigeria and found that population density drives electricity demand in Nigeria. His study adopted the multiple regression study and employed a time series data from the Nigerian economy from the period 1985 to 2005. A study consistent with the findings of Ubani (2013) is that of Ngutsav and Aor (2014) who also found population to have a significant impact on the consumption of electricity in a Nigeria.

A study by Saidi and Hammami (2015) used a panel data consisting of SSA, North Africa and Middle Eastern countries from 1990 to 2012 to examine the relationship between factors such as population among others on energy consumption by using data from 1990 to 2012. The study employed the dynamic panel energy consumption model by means of a Generalised Method of Moments and found a positive effect of population on the demand of energy which was also statistically significant.

Additionally, the relationship between population and electricity consumption has been conducted in other countries outside SSA. An example is a study conducted by using data for Pakistan covering the period of 1975-2010. The study which employed the dynamic short-run causality test and the Wald-F statistics and found population growth to positively affect the demand of electricity in Pakistan. Also, the causality test depicted a unidirectional causality from population growth to electricity consumption which implies that population growth is a determinant of electricity consumption in Pakistan Zaman (2012). Likewise a study by Shaari et al. (2013) examined the relationship among population, energy consumption and economic growth. The granger causality test which was employed in the study also suggested that energy consumption is affected by the population in Malaysia.

Therefore since studies show the evidence of population affecting electricity consumption, population may as well be a determinant of electricity in SSA since the demand of electricity may affect electricity production.

3.3.2 Other factors that may affect electricity generation

- ***Institutions***

The term "institution" is used by the Secretary-General's High-Level Panel (HLP) of eminent persons on the Post-2015 Development Agenda to cover rules, laws and government entities, as well as the informal rules of social interactions. People are able to work together very peacefully and increase productivity through efficiency and effectiveness when proper institutions are put in place. Quality institutions protects the right of peoples; it also ensure that the lives of the people is better off than before and fair institutions also leads to impartiality in judgement. Institutions can be grouped into two; thus formal and informal. The main formal institutions are laws, contracts and formal public management processes, whereas informal institutions refer to broader norms and values that can influence behaviour. Essentially, institutions, both formal an informal explains how an authority works and manages its dealings, how the state and the society formulates its decisions, how these formulated decisions are implemented to produce results, and how the results are measured and accounted by these entities (OECD, 2015).

Further, there are empirical evidence that proves the need for institutions such as regulations in the production of electricity. Other studies also focused on the relationship between some institutions such as regulatory bodies and the performance of the electricity generation industries or facilities. Bergara (1997) suggested that, the generation capacity of electricity in the world can be increased when there exist a well-defined and reliable political institutions that will check the behaviour of the government and producers of electricity. The study employed a cross sectional data of 85 countries and adopted the Ordinary Least Squares (OLS) to estimate the relationship in his study which showed the existence a positive correlation between political institution credibility and electricity generating capacity. Similarly Bacon and Besant-Jones (2001) posit that the economic performance differences in countries can also be explained by the political and institutional structures in countries. They postulated that political and institutional factors have the potential to determine the output in a country. In short, they speculated that the output of country is likely to be higher when a country has a comprehensive law and order and protected property right.

Steiner (2001) by using the random effect panel regression model in his study which was cantered on examining the relationship between regulation, industry structure and performance in the electricity supply industry had a similar outcome. The study found regulations to positively impact the performance of the industry. The estimations confirmed the expected impact of regulations and industry structure on the performance of the electricity supply industry. Likewise Zhang et al (2004) by using the correlation matrix, detected a significant association between the sequencing dummy which suggest that regulations should be put in place before privatisation. This relationship is a positive relation. They claimed that effect of monopoly on production is curtailed when independent regulators are put in place before allowing for privatisation. This is because, private investors are more likely to invest their scarce resources and increase the capacity for electricity generation when a regulating system is structured before privatisation. Therefore, their studies found that the electricity availability will increase when an independent regulator is put in place ahead of the establishment of the facility for generating electricity.

Similarly, Xia and Hu (2009) postulated that decisions made by higher level authorities on electricity consumption are one very authoritative measure which can cause a decrement in the electricity consumption intensity in China. Also, Khanna and Rao (2009) conducted a study on the demand and supply of electricity in developing countries. They argued that aside the government ability to intervene in the electricity sector, the government does intervene in the sector in so many other ways. They suggested that government can intervene in the electricity sector through its influence on the retail price as well as the setting the price for needed inputs for the production of electricity. These interventions by the government has the tendency to affect consumption decisions and selection of inputs. Additionally, the interventions by the government can lead to the employment of efficient technologies that may lead to higher productivity.

- ***Privatisation***

Privatisation is when the ownership and rights of a business or property is transferred from a government to a private investor or entity (Investopedia, 2015). Mostly, this transfer of ownership occurs when public properties are not efficient. Therefore privatising the business or public entity is used to enable efficiency.

Pettinger (2011) postulated that privatisation improves the efficiency of any business entity. Private firms are motivated by profit and therefore they will cut down cost in order to maximise profit. But government properties do not have mangers who directly benefit from the profit of the business so they may inefficiently manage the firm. Accordingly efficiency in a government property cannot be compared to the efficiency in a privatised entity. However, Pettinger (2011) then concluded that, privatisation can be a good or a bad depending on three things, thus: the industry, regulators quality, and private monopoly.

Also there are empirical studies that have also investigated the effect of privatisation on the performance of the electricity industry. A study that investigated the performance of the electricity sector found out that countries do not practice privatisation have a lower efficiency in the power sector as compared to the countries that have allowed privatisation in the sector (Hawdon, 1996). Steiner (2000) by using a panel of time period of 10 years and a cross section of 19 OECD countries, conducted a study to investigate the impact of liberalisation and privatisation on performance in the generation of electricity sector. He found private ownership to have a significant effect on the performance in the electricity sector. A similar claim was made by Parker (2003) basing his suggestion on the experience of the UK .He postulated that labour productivity which is a measure of performance increases when public utilities such as electricity is privatised. This was revealed through the profit that investors gain when there is an improvement in the performance of the privatised business at the initial stage and also by the substantial reduction in prices paid by consumers for the service. However he also claimed that the performance increment occurred at the time where there existed privatisation, competition, regulation and technological change and that productivity may fall even when managers are not pressured by competition and a regulatory body to work efficiently.

However, Vicker and Yarrow (1991) argued that the efficiency of a privatised firm depends on the nature of the game that exist between the firm and the government. There is the tendency of a government to enforce a reduction in prices by the privatised firm after the firm has made a sunk investment into the infrastructures of the firm. Such investments have long run benefits and more efficient that the short term investment. However, the probability of the government reneging the contract is high under such a circumstance therefore it will prevent investors from choosing a sunk investment. They also supported the claim by Parker (2003) and postulated that the indication from the experience of most privatised firms show that private ownership is not any better than public ownership; what makes the difference is competition. Also, Vicker and Yarrow (1991) argued that as a result of the differences in the economic nature of different countries, policies that worked for developed countries may not work for developing countries.

The impact of privatisation on the performance on electricity in the developed countries may vary from that of the developing countries because of the differences in the market and the level of development. Therefore other studies paid much attention to the effect of privatisation on performance in developing countries. A study that used the DEA analysis to compare the efficiency in the production of electricity in 27 developing countries had a very interesting result which is consistent with the claim of Vicker and Yarrow (1991). Their findings showed an evidence of no superiority between the public sector producers and the private sector producers (Junos and Hawdon, 1997). A study consistent with this study was conducted for 36 developing countries by Parker et al (2006). They found an insignificant effect of privatisation on performance. However, their studies found a significant positive effect for the interaction between privatisation and competition as well as privatisation and regulation.

Also, Stern and Cubbin (2006) used the fixed effect model to investigate the impact of regulatory governance and privatization on electricity industry generation capacity in developing employed data for 28 developing countries to investigate the effect of privatisation on the generation capacity level. They grouped privatisation into three different categories and investigated the effects of these categories of privatisation on the generation capacity level. The categories were: minority privatisation, majority privatisation and full privatisation. Their study found minority privatisation as well as full privatisation to have an insignificant effect on the level of electricity generation capacity. However, there was a 10% significant effect of majority privatisation on generation capacity in the long run.

- ***Renewable and non-renewable sources.***

The employment of either a non-renewable source of power generation or a renewable source of power generation has gained the attention of many policy makers. This is because of the advantages and disadvantages that comes with the use of either of these two source for the generation of electricity.

Few studies have investigated the relationship between renewable and non-renewable source for power generation. Koroneous' et al. (2001) in their study, exergy analysis of the renewable energy sources used three systems whose inputs are renewable energy source to investigate the efficiency when renewable energy source is used as an input. They found that some of the systems have a high level of efficiency when renewable energy source was used than when non-renewable energy source was used as input in the systems. They then argued that, the use of renewable source of energy is more efficient and also advantageous because of the fact that it is environmentally friendly and although it has its disadvantages, those disadvantages are offset by its inexhaustible nature.

Additionally, Tiwari (2011) used a Panel VAR to analyse the comparative performance of renewable source and non-renewable on CO2 emissions in Europe and Eurasian countries for the period 1965 to 2009. He found out that non-renewable source to be a factor that increases CO_2 therefore he recommended that the use of clean energy should be increased so as to increase employment and also preserve the environment. Similarly a recent study by Whittingham (2014) conducted an economic review of the Ontario Green Energy and Green Economy Act. His work was based on the effectiveness of the policy that endorsed the substitution of coal-fired electricity generation plants for the wind turbines and solar plants. The economic assessment in the study considered how the policy will help the province of Ontario to decrease carbon emissions as well as reduce the dependence on fossil fuels but increase employment. He found out that wind turbines are inefficient therefore, relying on it for power generation is not feasible. Eventually, fossil fuel will be needed as a back which will unfortunately lead to a higher carbon emissions in Ontario.

- ***Labour***

Upon reading several literatures, most studies have neglected the effect of labour on the generation of electricity. However, its effect on the consumption of electricity has received a lot of attention. Nevertheless, based on theory, the effect of labour on the production of electricity ought not to be ignored, especially in a production function. Therefore this study incooperates labour in the model used for the study.

3.4 Conclusion

The theoretical review is guided by the production function. The choice of the production function being the basis for this study lies on the premise of the technical relationship that exists between output and the input factors of production. Also, the chapter proceeded to review the empirical literatures on the causes and factors that affects electricity consumption and electricity generation. Empirically, little attention has been paid to the effect of institutions on electricity generation and effect of other factors that affects demand for electricity generation in SSA. Most of these studies also focused more on the causality between electricity generation or consumption and economic growth however, little attention has been given to the intensities of these factors on electricity generation in SSA. Therefore this study is conducted to bridge this gap.

CHAPTER FOUR

METHODOLOGY AND DATA SOURCES

4.1 Introduction

This chapter discusses the methodology used in the study. Firstly, the chapter discusses the theoretical framework which served as a building block for the estimated model. Then the chapter proceeds to specify the model used in this study. Further, it discusses the estimation technique then gives reasons for the choice of variables used in this study. The chapter lastly touches on the data source used for the empirical estimation of the study.

4.2 Theoretical Framework

The theoretical framework used for this study is based on the production function which was derived from the theory of production. This theoretical model is used to analyse the production of firms, industries, sectors and at the economy level (Mishra, 2007). The production function is a mathematical representation of the output that an industry or firm is capable of producing from a combination of different inputs. It shows the functional relationship between the output of a firm and the input of that firm. Mathematically, the production function can be represented by:

$Q = f(X)$……………………………………………………………(1)

Where

Q = quantity of output

X= vector of the inputs that affect production

The function above shows that the amount of output (Q) produced is dependent on the inputs.

Generally the production function is algebraically presented in the form

Q = f (L,K,M,D,S,P)

Where

Q = amount of output,

L = labour

K = capital

M = raw material

D = Land

S = return to scale

P= efficiency parameters.

4.3 Model Specification and Empirical Framework.

The study adopts a model that describes the relationship between the variables of interest used as explanatory variables and electricity generation. Below is the equation that connects the explanatory variables and the dependent variable.

EG = f (GDP per capita, Population growth, labour, Urbanization, Regulatory Quality, Privatisation)

Where EG is electricity Production.

In order to investigate the various factors that contribute to electricity generation, the study starts with a standard panel model specified below. The fundamental equation used for the study is specified below.

$$Y_{it} = \alpha_i + \sum_j \alpha_j X_{jit} + \sum_k \gamma_k Z_{kit} + \sum_l \delta_l M_{li} + u_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

Y_{it} is the dependent variable

i (i = 1,2,……..,N) in the period t (t=1,2,……,T)

N is the total number of countries

T is the total number of time periods

$\alpha_{i,}\alpha_{j}, \gamma_{k,}\delta_{l}$ are vectors of unknown parameters to be estimated.

X_{jit} is a vector of *j* explanatory variables, varying in time and by country.

Z_{kit} is a vector of *k* unobservable country characteristic variables.

M_{li} is a vector of *l* variable, varying by country but constant over time

u_{it} is the error term

(NB: $k = j + 1$)

The error term can be broken down as follows:

$u_{it} = \mu_i + \lambda_t + v_{it}$ ………………………..(3)

Where:

μ_i is the unobservable country specific effect

λ_t is the unobservable time effect

v_{it} is a new random error term

Therefore Equation (2) can be rewritten as

$y_{it} = \beta_i + \sum_j \beta_j x_{jit} + \sum_t \lambda_t D_t + v_t$……………….(4)

Where

y_{it} is dependent variable

β_i is a vector of overall and N – 1 country-specific intercept terms

D_t is a vector of T – 1 time dummy variables

x_{jit} is a vector of explanatory variable

β_j is a vector of associated unknown parameter

The empirical model employed in this study is adapted from the study of Bergara et al. (1997) and Parker et al. (2006). Following the model specification presented above the empirical model is derived and specified below:

$$y_{it} = \beta_i + \sum_j \beta_j x_{jit} + \sum_t \lambda_t D_t + v_t \text{..................}(4)$$

Where

y_{it} is dependent variable[1]

i (i = 1,2,……..,14) in the period t (t=1,2,……,16)

β_i is a vector of overall and N – 1 country-specific intercept terms

D_t is a vector of T – 1 time dummy variables

x_{jit} is a vector of explanatory variable[2]

β_j is a vector of associated unknown parameter

[1]The dependent variables that are not in the form of percentages will take the log form
[2] The explanatory variables that are not in percentages and indexes take the log form

4.5 Variables Description and Expected Signs

There are several factors that determine electricity production. Based on the objective of the study coupled with the literature reviewed led to the choice of the variables in the study and their expected signs.

4.5.1 Dependent variable

The dependent variables for this study were chosen based on the topic for the study and the objectives of the study. The dependent variables are specified below:

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- ***Electricity Generation per capita***

Electricity generation per capita measures the amount of electricity produced per capita of the population. The dependent variable was calculated by dividing the total electricity produced in a country annually by the total population in a year. It is a continuous variable that measures the amount of electricity available in a country for consumption in the 14 SSA countries.

- ***Hydroelectricity Power Generation.***

This dependent variable is in a form of a percentage. Since hydroelectric power source is the commonest source of generation of electricity in most of the 14 SSA countries, the study employed it as a dependent variable to investigate the relationship between hydroelectric power generation and the explanatory variables and also, to investigate the relationship it has with the other alternative sources of power generation, thus, the fossil fuels (oil, coal and gas) which is not environmental friendly.

- ***Non-Renewable Source of Generation***

Non-renewable source of generation is one of the commonest source of power generation in SSA so it is used as a dependent variable to probe the relationship between it and the explanatory variables. It is a continuous variable.

4.5.2 Explanatory Variables

The independent variables used in this study were chosen based on the literature reviewed and the objectives of the study. The variables used in this study are defined and the expected signs of the variables are explicitly stated below:

- ***GDP per capita***

The GDP per capita is used as a proxy for measuring the income level of the residents of a country. The GDP per capita is also an indicator of the level of economic activities as well as income a country. Since most economic activities may need electricity to operate, the level of economic activities as well as the level of income may affect the electricity demanded. An increase in the demand for electricity may induce the generation of electricity to satisfy the demand. Likewise an economy which is booming may demand a higher amount of electricity that may cause electricity producers to generate more electricity to meet the demand.

Therefore the expected sign of GDP per capita on electricity generation is positive. It is a continuous variable.

- ***Population growth***

The population growth variable is expressed as a percentage. Population growth is expected to be a factor that affects the demand for electricity. It is expected that a rise in the population growth should lead to an increase in the demand for electricity which may lead to an increase in the production of electricity since electricity demand affects the supply of electricity (Anonymous, 2007). Therefore the expected sign is positive.

- ***labour***

Labour serves as a very important input in production theory. It is expected that as the efficiency of labour in a country rises, the production in a country will increase, including the electricity industry. Therefore the expected sign of this variable is positive. This variable represents the total labour force in the countries understudy.

- ***Regulatory quality***

This variable is a proxy for measuring the effectiveness of institutions in the study. The regulatory quality index measures the supervisory work of regulators of businesses and firms that do not have competent quantitative controls. This indicator also measures the ability of the government to promote growth in the private sector through the formulation and execution of sound strategies. A good regulatory system in a country promotes private investors since it provides motivations for investment. A bad regulatory system may as well be a disincentive to private investors. Consequently, the regulatory quality may affect productivity in various sectors of the economy including the power sector which needs a quality regulatory system to function efficiently. The regulatory quality index is expected to take a positive sign.

- ***Privatisation.***

This variable measures the share (percentage) of the total generation capacity owned by private investors. The author obtained data on the total generation capacity and the energy investment by private participation from WDI. This variable was then constructed from the energy investment by private participation as a percentage of the total generation capacity. The data on the energy investment with private participation includes both the private and public investors however, critical scrutiny of the data shows that private investors contribute not less than 80% of the investments in the projects (Kirkpatrick et al., 2006 as cited in Parker et al., 2006). Therefore the use of energy investment by private participation to construct a percentage of the total generation to depict privatisation may be appropriate. The expected sign for privatisation is positive since private investors have the ability to increase the installed generation capacity and efficiency which may lead to an increase in generation.

- ***Electricity production from oil, coal and gas.***

This variable measures the electricity production from fossil fuels (oil, coal and gas) as a percentage of the total electricity production. They are non-renewable sources of power generation which is an alternative to renewable sources of electricity generation such as hydro. This variable is introduced into the regression when hydroelectricity source is the dependent variable. It can ether take a positive sign or a negative sign depending on the kind of relationship existing between the three fossil fuels and hydro source of electricity production. A negative sign shows substitutability and a positive sign depicts complementarity.

4.6 Method of Analysis

The empirical analysis employs panel data to examine the determinants of electricity generation in selected SSA countries. As a result, panel data techniques are employed in the analysis. This approach is advantageous when used for estimations than the conventional time series and cross sectional technique. This is because, panel data techniques makes use of both the time series properties and cross sectional properties in its estimation. Therefore, making the estimations from a panel data model more robust than the estimations from either a time series or cross sectional analytical technique.

4.6.1 Advantages of Panel Data.

There are several advantages associated with the use of panel data for economic analysis. Firstly, since the panel data factors in the individual-specific variables in its analysis, it accounts for the problem of heterogeneity among the cross-sections.

Secondly, since the panel data comprise a combination of time series and cross-section data, it allows more degrees of freedom which is usually not the case when a time series or cross-sectional model is used. Additionally, the availability of a higher number of observations allows more variability in data and multicollinearity is also reduced. Thirdly, the problem of aggregating data which is usually associated with time series is lessened when a panel dataset is used for the analysis. Fourthly, panel data have an advantage over the conventional time series and cross-section data because of its ability to give a better measurement as well as identify effects that are not usually detected by time series and cross sectional data. Fifthly, panel data analysis is able to give unbiased estimates even when there are missing observations in some time periods or for some cross sections. However, such cases in time series will demand the dropping of these missing observation which may be very important, thus leading to a biased estimation. Consequently, the use of panel data for this study is very appropriate because of the problem of missing observations which is usually associated with SSA data.

4.6.2 Fixed effects and random effects model

Panel data analysis usually makes use of either the fixed effects model or the random effects model. *The fixed effects model* is characterised by having different intercepts for each entity, but a constant slope for all the entities. The assumption behind the different intercepts in the fixed effects model is the omitted variable effects. The varying of intercepts of cross sectional unit is to absorb the effect of all omitted variables that do not vary over time but differ across entities. The fixed effects model has its merits and demerits. The fixed effects model has the advantage of allowing for error terms which correlate with the individual specific effects. However, there exist some disadvantages associated with the use of a fixed effects model for panel data analysis. A major disadvantage is the problem of multicollinearity and a loss of degrees of freedom that normally occurs when several dummy variables of many cross sectional units are used in the model. Additionally, the presence of autocorrelation which is specific to a cross sectional unit may lead to a biased estimation.

The *Random effects* model is different from the fixed effects model in so many ways. The random effects model's intercept is rather a random outcome variable. This random outcome variable is a functional combination of a mean value and a random error. Therefore, it implies that the error term of the cross sectional units measures the random deviations from the constant to the cross sectional units. One very important feature of the random effects model is that the cross sectional units have their error terms being constant over time. Also, the error term of the cross sectional units should not be correlated with the errors of the explanatory variables in the random effects model. Additionally, the model allows time invariant explanatory variables to be included in the model because of the specification of the intercept in the model.

The study employed the random effects and the fixed effect model to estimate the effect of the dependent variables of interest on the regressors. This approach has an advantage over other techniques because of its ability to control for country specific factors that may not have been factored into the model. The difference between the random effects model and the fixed effects model is that the random effects model has a country specific error term whereas the fixed effects model rather has a country specific intercept. The Hausman test will be applied to test which of these models is more suitable in the study.

4.6.3 Choice between fixed effects and random effect models

The Hausman test is used to make a choice between the fixed effects model and the random effects model for a panel data analysis. The Hausman test is able to detect which of these two models is superior to the other. This test detects if there exists any significant correlation between the explanatory variable and the cross sectional unit random effect. The existence of a significant correlation between the cross sectional unit random effect and the explanatory variables show that, the fixed effects model is superior to the random effect. If there is a correlation, the estimations of the random effects model will be inconsistent. However, if there exist no correlation between the explanatory variables and the cross sectional unit random effects, the random effects model is the ideal model for a consistent estimation. The null hypothesis for the test is that there exist no correlation between the cross sectional unit random effect and the explanatory.

4.7 Data Source

The study uses secondary data on 14 SSA countries for the period 1996 to 2011. The data were sourced from the World Bank's World Development Indicator (WDI) 2015 and the Worldwide Governance Indicator (WGI) 2010. The WDI and the WGI have data for all the 48 SSA countries, however the problem of missing data for some of the very important variables needed in the study reduced the sample dataset to 14[3]. The year 1996 is the starting date for the data because of the problem of the availability of data in SSA. Also, 2011 is the final year in the dataset because it represents the last year at which the data needed for the study was available when this research was conducted. The dataset is an unbalanced panel because there are missing data for some variables some of the countries in some time periods.

4.8 Conclusion

The theoretical framework which underpins this study has been discussed in this chapter. The chapter has also developed the model to be estimated. The chapter further touched on the empirical model and defined the variables of interest. Lastly, the data source and the description of the data used in the study have been provided.

[3] The countries understudy are: Angola, Cameroon, Cote d'Ivoire, Democratic Republic of Congo, Ethiopia, Gabon, Ghana, Kenya, Nigeria, Republic of Congo, Sudan, Tanzania, Zambia and Zimbabwe.

CHAPTER FIVE

PRESENTATION AND DISCUSION OF RESULTS

5.1 Introduction

The descriptive statistics for the dependent and the independent variables employed in the study are presented and discussed in this chapter. The chapter proceed to perform a diagnostic test on the panel data. Then the results of the model suitable for the study is presented and discussed. However the study will not include South Africa in the estimations because of the very high advantage the country has in the production of electricity as compared to the other fourteen countries. Stata version 13 (StataCorp, 2011) was used for the estimations of the study.

5.2 Descriptive statistics

This section presents the descriptive statistics of the dependent variables as well as the independent variables in the study. The statistics reported in the study includes the overall mean, the variations of the mean of dependent and the explanatory between countries and within countries. The panel is an unbalanced panel with 14 countries as the entities over a time period of 16 covering the period 1996-2011.

Table 5.1 Descriptive Statistics for Dependent Variables.

variable		Mean	Std Dev	Min	Max	Observation
lgenpc	overall	5.3370	0.935	3.233	7.122	N = 224
	between		0.941	3.563	7.043	n = 14
	within		0.217	4.115	6.243	T = 16
HYDRO	overall	69.199	25.273	20.810	100	N = 224
	between		23.396	32.028	99.701	n = 14
	within		11.323	36.646	103.80	T =16
Non-renewable	overall	27.842	25.496	0.000	79.100	N = 224
	between		23.970	0.299	67.972	n = 14
	within		10.682	-6.760	60.395	T = 16

The average means for the dependent variables which are log of electricity generation per capita, hydroelectric power generation and non-renewable power generation are 5.337 kwh/per capita, 69.199% and 27.842% respectively. Also, the variations in the mean across countries for the three dependent variables is higher than the variations within. This implies that different countries tend to contribute differently to the total amount electricity generation as well as the two sources of power generation than an individual country does over a period of time.

Table 5.2 Descriptive Statistics for Independent Variables

Variable		Mean	Std Dev	Min	Max	Observation
Regulations	overall	-0.831	0.576	-2.413	0.141	N = 156
	between		0.552	-1.826	-0.136	n = 12
	within		0.226	-1.622	0.201	T = 13
Privatisation	overall	0.916	5.186	0.000	70.961	N = 224
	between		1.136	0.000	4.435	n = 14
	within		5.069	-3.519	67.441	T = 16
lGDPPC	overall	6.580	0.896	4.872	8.940	N = 224
	between		0.910	5.104	8.787	n = 14
	within		0.170	6.163	7.031	T = 16
llabour	overall	15.854	1.146	12.893	17.751	T = 224
	between		1.180	13.081	17.557	n = 14
	within		0.126	15.603	16.108	T = 16
Pop Growth	overall	2.489	0.589	0.107	3.540	N = 224
	between		0.541	0.861	3.194	n = 14
	within		0.273	1.736	3.760	T =16

A number of regressors have the variations in the mean between countries higher than the variations within countries. The average of the regulation quality is -0.831 unit and the variation is higher across countries than within countries. Likewise, with a mean of 6.580 units, GDP per capita's variability in the mean is greater between countries than it does across countries. Also, the variation in the mean of labour and population growth are higher across countries than across countries. The average of labour and population growth are 14.854 units and 2.489% respectively. The implications of the variations of these variables across countries being higher than the variation within is that different countries contribute differently to electricity generation than an individual country does over time for these variables. This shows that the use of a panel for such a study will give robust estimations than employing a time series.

Also, the mean of privatisation is 0.916% however the standard deviation of privatisation within countries is higher than across the countries. This shows that privatisation tend to vary with time within a country than it does across the countries understudy. Therefore this variable is a very essential explanatory variable for such a study.

In short, from the descriptive statistics, there is a significant variability in the mean of the variables of the across and within countries for the explanatory variables which may have a significant effect on the generation of electricity. The variability of the variables across countries and within countries is substantial therefore, there is evidence of the existence of a panel effect from the dependent variables to the explanatory variables. Consequently, the study employed a panel data regression to probe the significant effect of the variables of interest on the dependent variable.

5.2 Correlation Matrix

The test of the correlation among the variables is very important since it detects the presence of multicollinearity among the variables used for a regression. This test is used to discover the strength of the relationship or association among variables. The interest is mostly on the strength of the association between the dependent and independent variable. The pairwise correlation matrix was used to test correlation between the variables in the study (see Appendix C).

The correlation matrix shows that labour and population growth has a negative relationship with electricity generation per capita. Also, the relationship between three explanatory variables (regulation quality, privatisation and GDP per capita) and electricity generation per capita is positive. On the contrary, GDP per capita has a negative relationship with hydroelectric power generation likewise regulation quality, labour and population growth. Privatisation is the only variable that depicted a positive relationship with hydroelectric power generation. Also, the correlation matrix shows a positive effect between GDP per capita, population growth and non-renewable source of power generation. However, regulations quality, privatisation and labour have a negative relationship with non-renewable source of power generation.

The p values which shows the significance of the correlation between the variables suggests that the relationship between electricity generation per capita and all the explanatory variables (Regulation quality, GDP per capita, labour and Population growth) with the exception of privatisation is significant. Also, regulation quality, GDP per capita, population growth have a significant relationship with hydroelectric power generation. Similarly, GDP per capita and population growth has a significant relationship with non-renewable source of electricity generation. The implication of the significant relationship between the three dependent and the regressors shows that the independent variables have the power to affect electricity generation per capita.

Generally, the correlation between independent variables are within the required range since correlation coefficients are within the accepted range.

- ***The VIF test for correlation***

Additionally, the VIF test for correlation was also conducted to prove that the correlations between the independent variables are within the accepted range (see Appendix C). Since the Mean VIF is less than 10, the correlation between the explanatory variables is acceptable and these variables can be used as independent variables in the study.

5.3 Diagnostic test

There is the need to conduct a diagnostic test before the use of a panel. The diagnostic test is usually conducted to ascertain the time series properties and the cross sectional properties of the panel. Additionally, the use of panel data for analysis is exposed to the problem of heteroscedasticity across the cross sectional unit as well as serial correlation across time periods. The presence of heteroscedasticity and serial correlation may lead to biased results. Therefore there is the need to conduct a diagnostic test to verify whether there exist serial correlation or heteroscedasticity. The diagnostic test is normally conducted on the residuals to check for heteroscedasticity and serial correlation in the panel. If there is a presence of serial correlation or heteroscedasticity, it will be corrected so as to prevent biased estimations.

The Woodridge test is used to test for the presence of autocorrelation in a panel data and a modified Wald test used to test for groupwise heteroscedasticity (see Appendix B). Since both test are significant at the 5% level, we reject the null hypothesis. Therefore, from the two tests, there is evidence of the presence of serial correlation and heteroscedasticity in the panel data. The presence of heteroscedasticity and serial correlation may not affect the unbiasedness and consistency of the estimated coefficient. However, the standard errors will be biased therefore it is important to correct the presence of heteroscedasticity and serial correlation in the panel. One way of correcting this problem is by transforming the variables of interest using the Feasible Generalised Least Square (FGLS). The transformation of the variables by the FGLS eliminates the heteroscedasticity and serial correlation in the standard errors. The disadvantage associated with the use of FLGS for a panel transformation is that the true variation in the sample can be underestimated. This is usually caused by the standard deviations of the coefficients estimated after the use of the FGLS (Hans, 2008). Additionally, the measurement errors that are usually associated with the transformation can lead to the estimation of a biased coefficient (Aboagye et al., 2008). Aside the use of the FGLS to correct the problem of heteroscedasticity and autocorrelation, there is another better way of correcting these two problems in a panel data analysis, that is, the use of the option of a robust standard error in the estimation of the model. The robust standard error, when used in a panel regression is able to account for both heteroscedasticity and autocorrelation without transforming the data. It is therefore advantageous to use the robust standard error than the FGLS because of the disadvantages associated with the transformation of the data.

5.3 Regression results

The fixed effects model and the random effects model were considered for the analysis of the study. However, based on the results of the Hausman test, the preferred model was used for the analysis of the study. The Hausman test is able to detect which of these two models is superior to the other. The Hausman test detects if there exist any significant correlation between the explanatory variable and the cross sectional unit random effects. The null hypothesis of the test is the random effects is the preferred model and the alternative hypothesis is the fixed effects model is preferred. When the null hypothesis is rejected, it implies that cross sectional unit random effects are correlated with the regressors, therefore the fixed effects model is superior to the random effects model. However if we fail to reject the null hypothesis then the random effects is preferable which implies that there is no correlation between the unique errors and the explanatory variables.

Below is the results of the Hausman test

```
. hausman fe

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
      lgdppc |    .4109824     .6067284       -.195746        .0382339
       lbour |    .7005575      .348965       .3515924        .0672369
privateinv~s |    .0055261     .0042611        .001265               .
Regulatory~e |    -.010712    -.0676127       .0569007               .
Population~l |   -.0844794    -.0968126       .0123332               .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       22.05
                Prob>chi2 =      0.0005
                (V_b-V_B is not positive definite)
```

Based on the results of the test, the null hypothesis is rejected which implies that the fixed effects model is suitable. Since the fixed effects model has been proved to be superior to the random effect model, the robust standard error estimation will be used in the fixed effects model.

The result of the estimated fixed effects model with the option of a robust standard error is presented below:

Table 5.7 Regression Results

Variables	Electricity generation per capita	Hydroelectric power generation	Non-renewable power generation
	Regression 1	**Regression 2**	**Regression 3**
LGDPPC	0.411*	1.775	4.667
	(0.196)	(2.284)	(2.921)
POP GRWTH	-0.084***	-0.385	-0.371
	(0.014)	(1.105)	(1.111)
LLABOUR	0.701***	1.775	-2.970
	(0.150)	(4.756)	(3.945)
REG. QUAL.	-0.011	-0.730	-0.222
	(0.073)	(1.480)	(1.420)
Privatisation	0.006***	-0.047	-0.052**
	(0.001)	(0.033)	(0.022)
Non-renewable		-0.967***	
		(0.452)	
Hydro			-0.872***
			(0.103)
sigma_u	1.275	12.251	9.492
sigma_e	0.133	4.027	3.824
Rho	0.989	0.903	0.860
R-squared	0.231	0.784	0.846
Prob>chi 2	0.003	0.000	0.000
Number of obs.	156	156	156

*** significant at 1%, ** significant at 5%, * significant at 10% , standard errors in brackets.

The analysis of the table above is presented below.

- ***Log of Electricity generation per capita.***

The results for the first regression shows that regulatory quality has an insignificant relationship with electricity generation. This result is consistent with the study of Parker et al. (2006). The insignificant effect of regulation infers that regulations on its own may not necessarily have a significant effect on electricity availability in these SSA countries. This may be due to the fact that most electricity generation facilities in SSA countries are state-owned. The government in power mostly govern such very important public utilities even with the existence of regulators. Therefore regulators may not have much control in the electricity generation industry in SSA countries.

However, privatisation was found to have a significant effect on electricity generation in the first regression. As expected, the estimation show that an increase in privatisation leads to an increase in the productivity of the electricity industry and the effect is strongly significant at the 1% level. An influx of private investors may lead to an increase in investment in the electricity production facility such as long term investment into infrastructure in the industry. The objective of private investors is to maximise profit and also, managers of a privatised facilities will be motivated to impress shareholders so they will adopt more efficient strategies which may positively affect productivity. Additionally, privatisation usually leads to deregulation which allows for competition and competition enhances efficiency which may translate into higher productivity in the production of electricity (Hawdon, 1996).

Also Gross Domestic Product per capita has a significant relationship with electricity generation which is significant at the 10% level. This indicates that electricity generation is increased when GDP per capita increases, holding other factors constant. This result is consistent with Parker et al. (2006). GDP per capita serves as an indicator of the level of income of a country. Since demand for a commodity is usually determined by the income level and prices, the income level in a country is key in determining the demand for electricity in a country. A study by Ferguson (2002) found that electricity demand and GDP growth are positively correlated which means that, the consumption of electricity increases as GDP also increases. The demand side of electricity can affect the supply side because of the fact that electricity cannot be stored after generating and therefore the demand for electricity is key in determining the amount of electricity produced for supply. A study that supports this relationship postulated that demand is one of the very important factors that causes investment in the production of electricity to grow (Anonymous, 2007).

Likewise, the coefficient of labour shows a positive relationship between availability and labour. There exists a 1% significant effect of labour on the electricity generation per capita. This shows that labour force has a strong effect on productivity in the electricity generation industry. The effect being positive implies that an improvement in the labour efficiency in a country is able to affect the productivity in electricity. This findings is consistent with production theory which is the theoretical framework underpinning the study. Labour is a very important input that determines output. Therefore a more efficient labour force may increase the availability of electricity.

Surprisingly, the relationship between electricity generation and population growth is significant, but the effect of population growth on the generation of electricity is negative which is not expected. The unexpected effect may be due to the fact that population growth in SSA does not keep pace with growth in electricity and therefore as population is rapidly increasing, the per capita electricity generation will be falling.

- ***Hydroelectric power generation***

The second regression shows the effect of the explanatory variables on the production of electricity from hydro. From the table it can be seen that the effect of regulations on the generation of electricity from a hydro source is also not significant. Also, population growth, labour, GDP per capita were found to have an insignificant effect on electricity generation from hydro. This may be due to the fact that electricity generation from such a renewable source is more costly and therefore these factors may not have any strong effect on the production or investment of electricity from such a source. It is therefore not a surprise that privatisation has an insignificant relationship with electricity generation in the second regression with a negative coefficient. This finding is consistent with Parker et al. (2006). The cost involved in the generation of electricity from renewable sources such as hydro is more expensive. Therefore private investors who are mostly profit oriented will not invest in the generation of electricity from a hydro source. Also with the initial cost of investing in a hydro source of power generation being very high, a private investor may be reluctant to make such sunk investment in sub-Sahara Africa where the probability of government reneging on its part of the contract is very high. Consequently an increase in private investors into electricity may not have a significant effect on the generation electricity from a hydro source. Also, Kwakwa (2015) found the negative effects of environmental degradation and alternative source of power to outweigh the positive effect of trade and foreign direct investment on hydro source of power production. The falling cost of other renewable sources of power generation could attract private investors and this would in turn lead to an insignificant but negative effect on the generation of electricity from the hydro source.

- ***Non-renewable power generation.***

All the explanatory variables in regression (3) do not indicate a significant effect on the generation of electricity from a non-renewable source with the exception of hydroelectric power generation and privatisation.

Privatisation as an independent variable depicted a negative relationship the generation of electricity from a non- renewable source. The unsustainability of the non-renewable source of power generation could be the reason why private investors are not attracted. Therefore, an increase in privatisation will shift focus from the production of electricity from the non-renewable source to a renewable source which is sustainable such as solar, wind etc.

- *Relationship between hydro and electricity generation from non-renewables*

The sign of the coefficient of the hydroelectric power generation confirms the results suggested by the second regression which indicated that electricity generation from the three fossil fuels (coal, oil and gas) and the hydro source of power generation are actually substitutes. Even though the initial cost of producing electricity from a hydro source is high, the operational and maintenance cost is low as compared to the conventional sources used for producing electricity and it is sustainable. Also, the initial cost involved in the production of electricity from the three fossil fossils is cheaper but not sustainable. Therefore, the two sources of electricity generation can be substitutes.

Also, the second regression which has electricity generation from the three fossil fuels which is the same as non-renewable source in the model as a regressor showed that the generation of electricity from a hydro source and electricity generation from the three fossil fuels can be substitute. The production of electricity from a renewable source such as hydro is associated with its own advantages and disadvantages, likewise the production of electricity from a non-renewable source such as coal, oil, and gas. The renewable source of generation has an advantage of producing electricity with a very low emission of harmful gas to the environment as compared to other sources of generation. This makes the production of electricity from the renewable source more environmentally friendly. The lives of people and animals in an environment can also be harmed when such pollutants are released in the process of generation since their habitat is in the environment. The renewable resources are not limited in supply, so successive use of this resource will not lead to the running out of the resource. Therefore, the society may support the investment into the generation of electricity from a renewable source such as hydro, wind, solar among others since the production of electricity from a renewable source preserves the lives in the society.

However, electricity generation from hydro is not reliable since it depends on the climate change and the initial cost involved in such investments is very high when compared to the conventional way of producing electricity. Also, the production of electricity from non-renewable source is associated with a high level of pollution emitted in the process of generating power from a non-renewable source. Since these pollutants are very harmful to the lives of the people in the environment, the society may not be in support of the production of electricity by the use of this type of natural resource. Also, the fact that non-renewable resources are limited in supply shows that it is not sustainable. However, the production of electricity from the three fossil fuel is cheaper when compared to the production of electricity from hydro.

The result shows that the state can also substitute the production of electricity from the non-renewable source of generation for a renewable source which is less harmful to the environment and the lives of the people in the country since government is more concerned about the welfare of the people (Tiwari, 2011).

5.4 Conclusion

The objective of the study was to investigate the determinants of electricity generation in some SSA countries. The results of the fixed effect regression has showed that, some factors significantly affect the amount of electricity generated in the countries understudy.

CHAPTER SIX

SUMMARY, CONCLUSION AND POLICY RECOMMENDATION

6.1 Introduction

The chapter summarises the entire study and makes conclusions based on the findings of the study. Then policy recommendations which will inform policy makers of the right decisions to make in the electricity generation industries are also made based on the findings of the study. Finally, the chapter provides the limitation of the study.

6.2 Summary and Conclusion

Sub-Sahara Africa is characterised by shortage of electricity supply which normally leads to blackouts and brown outs. Therefore, aside the problem of low rate of accessibility the proportion of the population with access do not even enjoy a consistent flow of power which is due to the low generation of electricity. Although some policies have been put in place to curb this problem, the situation has not experienced much improvement. The electricity generation per capita of the countries are very low when compared to that of other African countries like South Africa among others. The low generation of electricity affects the availability of electricity for use in these SSA countries, therefore limiting their opportunities. This is because a continuous flow of electricity is very important to most sectors of the economy, especially in the health sector, education sector as well as the industrial sector. Also, the availability of electricity can help eradicate poverty in these SSA countries among others.

An overview of the electricity sector in SSA with much focus on the 14 SSA countries showed that electricity accessibility rate in most of the 14 countries is below 50%. This implies that 50% of the population in most of these 14 countries do not have access to electricity. This problem of low accessibility has caused the low consumption per capita in these countries. However, the problems of low accessibility and low consumption are as a result of the low generation of electricity in these 14 SSA countries. Generally, the trend in the growth of electricity generation per capita fluctuates and recent data even show a fall in the growth of electricity generation per capita. These reasons and many others motivated this study to investigate the factors that determine the amount of electricity generation.

As a result, the production function was employed to develop a model to investigate the factors that affect production. The study employed secondary data from the World Development Indicator and the Worldwide Governance Indicator. Based on the Hausman test, the fixed effects model was found superior to the random effects model for the analysis of the study.

The descriptive statistics showed that the dependent variables variability in the mean is high across countries. Also, there existed variations within and between the independent variables therefore the use of a panel analysis was appropriate for the study. The variables that were found to have a significant relationship with electricity generation per capita are Gross Domestic Product per capita, Privatisation and labour. When the hydropower was used as a dependent variable all the explanatory variables including privatisation were found to be insignificant. Nonetheless, the non-renewable source of power generation as introduced in the model depicted a negative and significant relationship which shows that the hydro source of power generation and the production of electricity from the non-renewables (three fossil fuels) are substitutes. Also, non-renewable source of power generation when used as an independent variable in the study showed an insignificant with non-renewable with the exception of privatisation.

6.3 Policy recommendations

- ✓ The results from the study has shown that policies that give rise to privatisation will lead to an increase in the electricity generation per capita in the 14 SSA countries. Therefore, this point out that government should create an enabling environment that attracts new generators to agree on a long-term purchases contract in the generation of electricity which may have a positive effect on the generation of electricity.

- ✓ Also, labour is found to significantly increase electricity generation therefore the industry can adopt a labour intensive method of production to increase productivity.

- ✓ Additionally since GDP per capita also positively determines electricity generation, the countries should focus on increasing the GDP per capita since it is an indicator of the demand in a country and purchasing power of consumers. Private investors are likely to consider the demand for electricity before investing in the electricity industry.

- ✓ Lastly since electricity generation from a renewable source, (hydro) and electricity from a non-renewable source (fossil fuel) can be substitutes, governments should consider the welfare of its people and invest more into the production of electricity from hydro since it produces less carbon and it is more sustainable.

6.4 Limitation of the study

Generally, one of the problems in researching in SSA countries is availability of data. The lack of data for some very important variables which would have made the study a better one served as a major problem in this research. Several studies have found a strong relationship between electricity generation and competition. However, as a results of limited data on competition in the electricity industry in the 14 countries, this very important variable was omitted. Also, a variable like prices, capital formation and investments was omitted because of the inability of the researcher to access the data because of financial constraints. Therefore further research should include these variables so as to know how they affect the dependent variable in SSA, since most studies find a strong relationship between them and electricity generation so as to inform policy makers on the right decisions to make.

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APPENDIX

Appendix A

Regression Results.

```
Fixed-effects (within) regression               Number of obs      =       156
Group variable: cd                              Number of groups   =        12

R-sq:  within  = 0.8891                         Obs per group: min =        13
       between = 0.7636                                        avg =      13.0
       overall = 0.7836                                        max =        13

                                                F(6,11)            =   1357.08
corr(u_i, Xb)  = -0.3874                        Prob > F           =    0.0000

                                         (Std. Err. adjusted for 12 clusters in cd)
```

hydro	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdppc	1.774921	2.283703	0.78	0.453	-3.251477	6.801318
lbour	-8.381221	4.756265	-1.76	0.106	-18.84969	2.087248
privateinvestors	-.0470373	.032575	-1.44	0.177	-.1187344	.0246597
RegulatoryQualityEsti~e	-.7295679	1.48009	-0.49	0.632	-3.987224	2.528089
Populationgrowthannual	-.3846409	1.105358	-0.35	0.734	-2.817517	2.048235
Electricityproduction~l	-.9665098	.0451942	-21.39	0.000	-1.065982	-.8670379
_cons	213.5129	67.57725	3.16	0.009	64.77635	362.2494
sigma_u	12.251014					
sigma_e	4.0267118					
rho	.90250007	(fraction of variance due to u_i)				

Fixed-effects (within) regression Number of obs = 156
Group variable: cd Number of groups = 12

R-sq: within = 0.8873 Obs per group: min = 13
between = 0.8390 avg = 13.0
overall = 0.8479 max = 13

F(6,11) = 168.19
corr(u_i, Xb) = -0.0367 Prob > F = 0.0000

(Std. Err. adjusted for 12 clusters in cd)

Electricityproduction~l	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdppc	4.666477	2.92119	1.60	0.138	-1.763018	11.09597
lbour	-2.969965	3.945811	-0.75	0.467	-11.65464	5.714706
privateinvestors	-.0524003	.0224995	-2.33	0.040	-.1019214	-.0028792
RegulatoryQualityEsti~e	-.2219859	1.420124	-0.16	0.879	-3.347658	2.903686
Populationgrowthannual	-.3707289	1.111347	-0.33	0.745	-2.816788	2.07533
hydro	-.871785	.1030777	-8.46	0.000	-1.098658	-.6449124
_cons	97.85162	63.69663	1.54	0.153	-42.34373	238.047
sigma_u	9.4420588					
sigma_e	3.8243015					
rho	.85907113	(fraction of variance due to u_i)				

```
Fixed-effects (within) regression               Number of obs      =       156
Group variable: cd                              Number of groups   =        12

R-sq:  within  = 0.4937                         Obs per group: min =        13
       between = 0.2867                                        avg =      13.0
       overall = 0.2310                                        max =        13

                                                F(5,11)            =      7.14
corr(u_i, Xb)  = -0.8246                        Prob > F           =    0.0033

                                   (Std. Err. adjusted for 12 clusters in cd)
```

lgenpc	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdppc	.4109824	.1959411	2.10	0.060	-.0202811	.8422459
lbour	.7005575	.1504897	4.66	0.001	.3693318	1.031783
privateinvestors	.0055261	.0009964	5.55	0.000	.003333	.0077192
RegulatoryQualityEsti~e	-.010712	.0729477	-0.15	0.886	-.1712688	.1498447
Populationgrowthannual	-.0844794	.0410562	-2.06	0.064	-.1748435	.0058847
_cons	-8.560625	3.369717	-2.54	0.027	-15.97732	-1.143929
sigma_u	1.2750349					
sigma_e	.13338377					
rho	.98917482	(fraction of variance due to u_i)				

Appendix B

Diagnostic Test

Test for autocorrelation

Woodridge test for autocorrelation in panel data

H0 : no first order autocorrelation

F(1, 11) = 7.645

Prob > F = 0.0184

Test for heteroscedasticity

Modified Wald test for groupwise heteroscedasticity in fixed effects regression model

H0 : sigma(i)^2 = sigma(i)^2 for all i

Chi2 (12) = 580.40

Prob > chi2 = 0.0000

Appendix C

Test for Correlation among variables

Pairwise Correlation Matrix

	lgenpc	Hydroelectric	Non-renewable	Regulations	Privatisation	Lgdppc	llabour	pop growth
Lgenpc	1.000							
Hydroelectric	-0.1797	1.000						
	(0.0070)							
Non-renewable	0.1575	-0.9558	1.000					
	(0.0183)	(0.0000)						
Regulations	0.1511	-0.1551	-0.0034	1.000				
	(0.0598)	(0.0532)	(0.9668)					
Privatisation	0.0253	0.0508	-0.0583	-0.0184	1.000			
	(0.7060)	(0.4492)	(0.3849)	(0.8200)				
Lgdppc	0.5929	-0.3189	0.3521	0.2038	0.0948	1.000		
	(0.0000)	(0.0000)	(0.0000)	(0.0107)	(0.1572)			
Labour	-0.6094	-0.0165	-0.0135	-0.0837	-0.1298	-0.8226	1.000	
	(0.0000)	(0.8057)	(0.8406)	(0.2987)	(0.0524)	(0.0000)		
pop growth	-0.4090	0.2885	-0.2972	0.3645	0.0393	0.0495	0.1042	1.000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.5588)	(0.4610)	(0.1199)	

The P values are in brackets

VIF test

Variable	VIF	1/VIF
LGDPPC	3.07	0.32
LLABOUR	3.02	0.33
POP GROWTH	1.28	0.78
REG. QUALI.	1.19	0.84
PRIVATISATION	1.02	0.98
Mean VIF	1.91	