THE IMPACT OF LOAD SHEDDING ON THE ECONOMIC GROWTH OF SOUTH AFRICA

BY

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Abstract

Load shedding is a process whereby the demand for electricity exceeds its supply which is experienced by power cuts or black outs. With an increasing demand for electricity consumption, supply seems to be limited, the study therefore seeks to identify the cause of load shedding and its impact towards economic growth. Eskom being the sole provider of electricity in South Africa is in most cases required to interrupt the supply of electricity in selected areas in order to undertake maintenance. The study analyses and identifies the significance of load shedding towards the economic growth of South Africa for the period of 1984 to 2014 with respect to the consumption of electricity. Using Engle Granger Cointegration test, the study aims to determine the relationship between economic growth and electricity consumption, Granger Causality test is performed to identify if one time series can be used to explain each other in the long run. The study finds electricity consumption to be significant towards economic growth, which indicates that load shedding has a negative impact towards economic growth.

Keywords: Economic Growth, Electricity Consumption, Load Shedding, South Africa

JEL Classification: C20, C22, C53, Q40, Q41,

DECLARATION

I, the undersigned, Mpho Lenoke, declare that this Dissertation, is my own work and all the material contained herein has been acknowledged. Furthermore, this Dissertation has not been previously submitted for a degree at this, or any other institution.

SIGNATURE

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Date

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I firstly like to thank my Supervisor, Prof. O.D. Daw for the support and guidance throughout this journey. Secondly I would like to thank my family for believing in me and supporting me. I would also like to acknowledge Mr. T. Mosikari for his contribution in assisting me to complete this dissertation. Last but not least, all glory goes to the almighty, God, for giving me the power and knowledge and making this possible.

DEDICATION

I dedicate this dissertation to my late brother In-law, Mr Lebogang Moile, who was my biggest supporter, a brother and a father I never had. This is possible because of him. May his soul Rest in Peace.

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LIST OF ACRONYMS

ADF	Augmented dickey-fuller
GDP	Gross domestic Product
EC	Energy Consumption
ECT	Error Correction Term
ECM	Error Correction Model
ESKOM	South African electricity public utility
Kwhcons	Electricity Consumption
Kwhp	Electricity Price
WB	World Bank
MW	Megawatt
MWH	Megawatt-hours
NGDP	Nominal Gross Domestics Product
NERSA	National Energy Regulator of South Africa
POP	Population
PP	Phillips-Perron
SARB	South African Reserve Bank

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CHAPTER ONE

1.1 Introduction

As a developing country, South Africa has been responsible for ensuring the supply of electricity to some parts of Africa, thus covering two-thirds of the continent's electricity supply (Winkler, 2005). South Arica plays an important economic role as a lead exporter of electricity to some parts of Africa that prove to have a high demand for electricity.

Cheng and Lai (1997) point out that it has been a common knowledge that capital labour and other factors of production are enhanced by energy. In their study of the causality between energy consumption and economic activity in Taiwan, Chang and Lai also pointed out that scarcity of energy resources, taking into account the increase in economic growth, led to a rapid increase in energy demand which resulted to a point whereby the country relies on importing electricity from neighboring countries. Resource scarcity does prove to play a role in increasing excess demand for electricity, while in the case of South Africa, even though there is excess demand for electricity, the country still plays a vital role in exporting energy. South Africa plays a leading role in the production and consumption of electricity in the African continent (Odhiambo, 2009).

A decrease in energy consumption will lead to a decrease in production, which in turn will have a negative effect towards GDP contribution along with employment. Odhiambo (2009) states that South Africa, compared to the rest of the world, charges less process for electricity which might be one of the reasons for the ever increasing demand for energy.

The robust economic growth does contribute towards the high demand for electricity in South Africa. Past the apartheid era, the new South African government was set to bring development and improve the standards of living for its citizens by providing social services such as housing, health facilities, water and sanitation, road and electricity. The provision of such social services led to an increase in the demand for electricity consumptions as the majority of the population of the country was once deprived from utilizing social services like electricity. The high demand for electricity accelerated during the years as in 2008, the sole supplier of electricity in South Africa being Eskom, was under pressure and forced to take necessary measures to avoid a system-wide blackout (Odhiambo, 2009). Such measure helped find a balance between the existing high demand and the supply of electricity. As by Eskom, load shedding takes place when the National Control Centre instructs its Distribution Regional Control Centres, 126 Municipalities and Eskom's key Industrial Customers on the Megawatts to be shed. These instructions are carried out by switching off individual areas for predetermined times as per published schedules. The duration of load-shedding depends on the specific Eskom region or on the Municipality, based on local circumstances.

1.2 Background statement

The study aims to identify the impact of load shedding towards the economic growth of South Africa. To better understand and learn more about the topic at hand, the relationship between the economic growth and the consumption of electricity is analyzed. The role of electricity has been identified as being of key importance to everyday everyday life (Adebola, 2011). Electricity and the role it plays towards the growth of the economy may be seen or considered as one of the many determinants of economic growth. As in the case of South Africa, the determinants of economic growth are of a central debate with respect to which elements are of most importance concerning economic growth (Fedderk & Romm, 2006).

Considering the rate how electricity is consumed in South Africa, it should be given priority because of its importance in economic growth. The supply and demand for electricity have proved to be the most important elements of planning for the country's electricity supplier (Imtriaz, 2006). Electricity plays a vital role in South Africa, taking into account the ever changing economic activities and new technological innovations which are electricity driven. With that being the case, sufficient electricity capacity should be available to support the ever changing technological innovations (Koen and Holloway, 2014).

According to Koen and Holloway (2014), taking into consideration of the increasing population of South Africa leads to an increase in demand for housing and social services, and in this case the demand for electricity also increases due to the role it plays in housing and other social services.

With limited information from the Department of Energy of South Africa about the accurate usage of energy in the different sectors of the economy, one can only assume that, given the highly production activities within both the secondary and tertiary sectors, not only in South Africa but also in most parts of the world, is where the high rate of electricity consumption takes place. The role of electricity consumption can be found in both the demand and supply side. Demanded energy is identified by utilization of customers for their own personal use, and with supply the role of electricity consumption is identified to be related with the production cycle (Fatai, 2014).

The problem of load shedding can be reasoned into two clusters, as load shedding is simply defined as a problem of supply and demand. The two clusters can be identified as the problem of infrastructure development or insufficient production of electricity for the country. The study looks into this matter in more detail. However, in the case of South Africa's electricity crises, the problem clearly lies with the demand and supply side. With the increasing population which the government must account for through social services like water, housing and electricity, it becomes rather hard for the state and the national electricity supply to keep up with the demand. The South African electricity supplier on the other hand faces many challenges when it comes to the production of electricity due to proven lack of infrastructure maintenance and development as seen in some power stations across the country that have been under the bridge of collapsing due to lack of maintenance.

Eskom as a sole supplier of electricity in South Africa, has to deal with the consequences of load shedding. One consequence is being financially unstable. With financial constraints taking place, the sole provider of electricity tends to increase electricity tariffs as approved by the National Energy Regulator of South Africa (NERSA) as seen in the past. Apart from increasing electricity tariffs, Eskom relies on the state for assistance as one of the state entities. The government has in many cases bailed out Eskom to ensure that the entity keeps on operating and continues to provide the nation with electricity. As the government takes such responsibilities, it should be noted that the bailouts can amount to billions of rands. For the government to get such funds, the fiscal policy is implemented whereby the state increases tariffs to generate income for the state. This goes to show that the toll that load shedding has as on Eskom as a supplier also affects the consumers in many ways.

The demand for electricity should be adhered to in order to meet with the supply side. Koen and Holloway (2014) pointed out in their study the methodology and the importance of forecasting electricity demand, reason being to ensure sufficient electricity that is set to meet the demand. The change in demand for electricity is mostly affected by changes in the economy and demography (Koen and Holloway, 2014). Forecasting entails looking into the future and preparing for it, and in the case of South Africa, given the imbalances of the past, the actual idea of forecasting the electricity usage should have been taken into account, considering policy changes and amendments prior to the democratic election as inclusivity took place prior 1994.

The topic of electricity consumption has received quite an attention over the years, more especially with the link between economic growth and electricity consumption (Fatai, 2014). Given the nature and the role of economic activities taking place every day, the importance and the role that electricity plays should be highlighted as it can be argued that the consumption of electricity can be classified as a compliment to economic growth.

From the context of economic growth, government expenditure plays a vital role and a key participant to growth. The role government plays towards the growth is looked at from its contribution towards energy production, it ensures that the nation is provided with electricity. With respect to electricity consumption, government expenditure plays an indirect role as to contributing towards economic growth (Akitoby et al., 2006).

Literature shows that electricity consumption plays a key role in the economy and its contribution can be identified easily. It is for this reason many studies have been conducted to better understand the relationship between electricity consumption

and economic growth as it the case with this study at hand, although the focus is more on electricity supply meeting the demand and the impact it has on growth.

1.3 Problem statement

Since 2008 the South African electricity supply has been under a lot of pressure given the increasing demand for electricity and lack of infrastructure to support and meet the increasing demand for electricity. Therefore the study takes into account the problem of load shedding with respect to high electricity consumption and the impact it has on the economic growth of South Africa.

Many studies have been conducted to understand the relationship between electricity consumption and economic growth. In most of these studies, literature suggests that there is a bidirectoral relationship between electricity consumption and economic growth, while it is assumed that other studies may suggests that there is a uni-bidirectoral relationship between electricity consumption and economic growth. Demand for electricity is a result to electricity consumption, which in the case of South Africa resulted to load shedding due to supply not meeting demand.

An increase in the demand for electricity puts the electricity supplier under pressure to meet the increasing demand for electricity. As to this case, the electricity supplier in South Africa being Eskom is faced with the responsibility of ensuring that the demand for electricity is met and ensure that there is enough power supply. Electricity capacity and its supply depends on the number of power plants available that will ensure that there is sufficient electricity supply. However the shortcoming of electricity supply is load shedding.

To take control of the load shedding and further get control of the increasing demand for electricity, new power plants that will be energy efficient are built to ensure that there is sufficient supply of electricity even when there is an increase in demand. The process of building these power stations comes with the pros and cons. In most cases the cons exceeds the pros to the point whereby there is more frequent power cuts when it involves the construction of the new power plants. Even further with this in process, the increasing demand for electricity leads to a point of an overload to the existing power stations or plants which directly leads to power cuts. It is seen as a necessary measure to ease the pressure from the electricity supplier. With that in mind, usually new power plants that are being built are occasionally running behind schedule more often due to technical failure, financial difficulties and in most cases labour issues.

With regards to the new power plants that are being built, the cost analysis of these plants is expected to cost about 38% more of what was estimated. Power constraints negate the advantage of improved transportation links that should be boosting the sales of many companies and even contributing directly to exports. In most cases the problems that are faced with regards to electricity supply requires government intervention to ensure that there is a continuer’s investment to infrastructure development.

1.4 Aims and Objectives

The aims of the study at hand are to:

- Identify and examine the impact that load shedding has on the economy of the country, taking into account the past and present status of the country’s energy crisis.

- Analyze whether energy has a direct impact towards the growth of the South African economy.

The objective of the study at hand is to:

- Analyze whether economic growth leads to an increase in the demand for electricity or rather find the causality between economic growth and electricity consumption.

1.5 Questions

The study aims to understand and answer the following questions:

- If load shedding is a strategy to combat electricity demand or not?
- Is load shedding regarded as a threat to economic growth or not?

1.6 Hypothesis of the study

- H0: Load shedding has a direct negative impact towards economic growth of South Africa
- H1: Load shedding does not have a direct negative impact towards economic growth of South Africa

1.7 Limitations of the study

- The study does not take into account the impact that load shedding has on the economic growth of neighboring countries that Eskom export electricity to.
- The study at hand is only limited to Eskom in the energy sector.
- The focus of the study is only 30 years and does not take into account years prior 1984 and up to 2014.
- The determining factor of load shedding is not counted for in the model.

1.8 Research Methodology

The study empirically examines the relationship of South Africa's electricity consumption and economic growth with respect to understanding the impact that load shedding has towards the economic growth of South Africa. A time series data collected from the South African Reserve Bank (SARB) and the World Bank (WB) ranging from 1984 to 2014 is used for the variables that can be used to explain load shedding and its impact to economic growth such as Growth domestic expenditure, Electricity consumption, Eleciticty Price, Income and Population which are used for the model of the study. For testing and analyzing, an econometric computer program called E-views is used. The study consists of the Augmented Dickey Fuller unit root test, Phillips Perron test, cointegration test, Granger Causality test and the error correction used to analyze and interpret the results for the study.

1.9 Significance of the study

The study aims to identify the impact that load shedding has to the growth of the economy of South Africa and what measures can be taken from the identified outcome of the study. The outcome of this study will help better understand the concept of load shedding, energy consumption and the role of both factors towards the growth of the country's economy.

1.10 Deployment of the study

Five chapters are furnished for this study as detailed below:

Chapter 1 details the flow of the study. The background and statement of the study is explained in detail, also the hypothesis and the main aim of the study are explained in this chapter along with the problem statement and significance of the study.

Chapter 2 reviews electricity consumption in South Africa and also takes into account the energy sector of South Africa.

Chapter 3 reviews the literature on the consumption of electricity and economic growth. Studies on the topic at hand are carefully looked into. The chapter further reviews the literature for electricity consumption and its impact on the growth of the economy.

Chapter 4 unpacks the research methodology used for this study. Variables used in the model of the study are analyzed along with the data used. Tests carried out in the study are also explained in detail.

Chapter 5 reveals the analyses carried out for the study. Results and interpretations from the test carried out are revealed to make concluding remarks, taking into account the hypothesis of the study.

Chapter 6 entails conclusions and findings of the study. Recommendations are also made with respect to the findings of the study.

1.11 Conclusion

This chapter of the study provides an insight to the topic of the study and how the study intends on carrying out the rest of the chapter to answer the research questions and achieve the objectives of the study. Furthermore study analyses and approach is introduced as to how the study will conduct its analyses.

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CHAPTER TWO

AN OVERVIEW OF ELECTRCITY CONSUMPTION AND ENGERGY SECTOR OF SOUTH AFRICA

2.1 Introduction

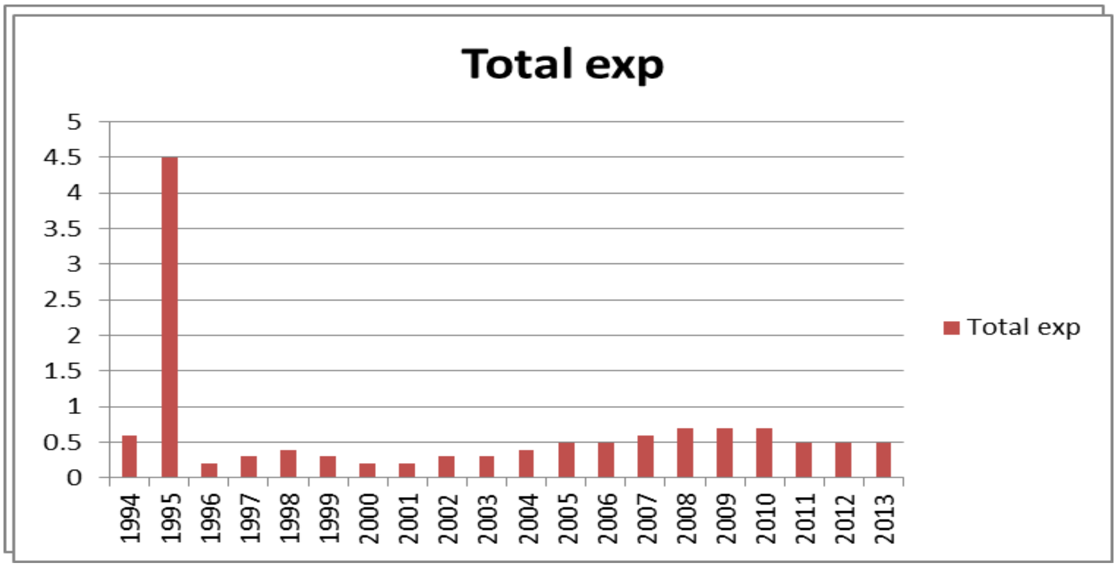
In this chapter, study facts are reviewed with respect to the energy industry and electricity consumption in South Africa, this taking into account other contributing factors to the energy sector, like the supply of coal for electricity generation. Understating the South African energy sector will help better understand the concept of electricity supply and demand.

2.2 Overview of electricity consumption and energy sector in South Africa

To better understand the correlation between electricity consumption and economic growth, several studies have been reviewed in this study to get a better concept of the two subjects at hand. A study conducted by Schutte et al. (2013) points out that an increase in energy demand is necessary as the economy grows. With that being the case, a problem is likely to occur when the demand for electricity exceeds the actual supply capacity. The study further indicates that, in order to reduce excess demand for electricity, additional power generation capacity is needed, and the construction process of increasing power supply capacity is most likely to involve power supply interruptions and other energy saving measures. Furthermore, the forever increasing demand for power is believed to be influenced by the mineral industry as it is a power intensive industry along with other major industries, especially when it comes to the production process. Eberhard et al (2008) highlights that, during the energy crises that South Africa faced during the year 2008 the economy experienced a downward growth was seen in the mineral industry as some mines had to be closed and that led to a reduction in total production along with exports rates and employment. All this affected the GDP of the country negatively to a point whereby there was no growth in GDP.

According to the study by Eberhard et al (2008), the energy crisis in South Africa was caused by insufficient generating capacity due to lack of investment programmes and other delayed programmes that were already put in place to adhere to the problem that the country was facing. Also adding to the case, Eberhard included coal supply problems and plants breakdowns which point out the maintenance problem that the country has when it comes to the electricity or energy containment.

Figure 2.1 Energy Expenditure in South Africa

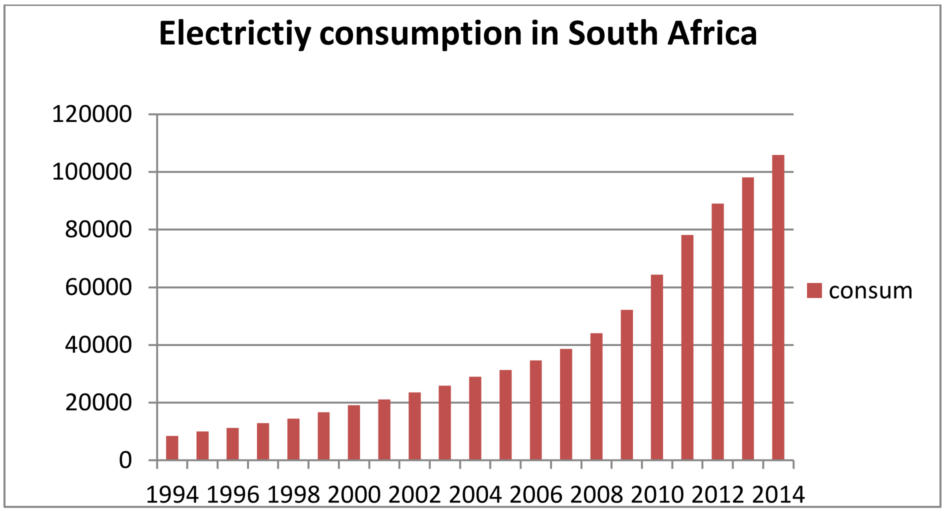


Source: South African reserve bank 2015

Figure 2.1 shows the total expenditure by the central state on energy, the country had the highest expenditure in energy investment during the year 1995 with an increase of 4.5% in total expenditure and from there of on there has been a constant decline in total expenditure as seen in 2001 whereby total expenditure was lower than 0.5%. However there was a slight improvement during the year 2009 with total expenditure being just over 0.5% of expenditure. As to this case, low investment can result to lack of maintenance of infrastructure and its development.

Aqeel and Butt (2001) argue that total electricity consumption is a direct consequence of economic growth and also concludes with the findings of direct employment which is influenced by electricity consumption. This entails that, with an increase in economy growth; there will be an increase in energy consumption which results to an increase in demand for energy. In order to cover the increasing demand for energy, there is a process of increasing the production process for energy generation capacity sufficiently for supply which in the other hand will be more labour intensive and in the end will have a direct impact towards employment.

Figure 2.2 Electricity Consumption



Source: South African reserve bank 2015

The above figure 2.2 illustrates the consumption of electricity consumption by the citizens of the country. According to the figure, as from 1994 till 2014 there has been a significant increase in the supply for electricity and this led to an increase in electricity consumption. The yearly increase of consumption can be linked with the increase in demand. In this case, an increase in demand automatically results to an increase in consumption, which concludes that there are more and more households, firms, local business and companies' that are demanding and utilizing more electricity which results to an increase in consumption.

Table 2.1: Electricity usage as source for cooking in South Africa

Geographic location	Urban formal	88
	Urban informal	72
	Rural areas	59
	Farms	64
Province	Western cape	81
	Eastern cape	71
	Northern cape	79
	Free state	90
	KwaZulu-Natal	77
	North-West	85
	Gauteng	84
	Mpumalanga	79
	Limpopo	49
Dwelling Type	Formal dwelling or Brick structure	82
	Traditional dwelling or hut	44
	Informal dwelling or shack	62

Source*: a survey of energy related behaviour and perception in South Africa (2013)*

The above table looks into how households use electricity on a daily basis.

The table is categorised into three sections, the geographical location, provinces and Dwelling types which look into how electricity is used in different households for cooking purposes. In every household around the world, the primary use of electricity is cooking. From the table above, under the geographical location indicates that urban formal areas use more electricity to cook as compared to other locations, with Free State taking the lead of 90% usage of electricity for cooking compared to other provinces.

Looking at the types of dwelling that use more electricity for cooking, the formal dwelling or brick structure indicates to be the dwelling type that has a high rate 82% of electricity usage for cooking. The consumption of electricity is broad, taking into account indications by statistics, and ranges from construction, manufacturing, agricultural and commercial sectors and households. This indicates the importance of electricity in today's vast economic activities and growth.

With respect to the increasing demand for electricity consumption, in an economic sense, an increase in demand will lead to an increase in process, whereas in the case of electricity consumption, an increase in electricity consumption will lead to an increase in prices for electricity for all the consumers. An increase in prices will eventually lead to a decrease in the demand for a commodity at hand. The concept of how consumers behave towards price changes is identified as a price elasticity of demand. Taking energy into account, price changes will not have the same impact to the rate demand as compared to other commodities, this is due to the fact that electricity consumption has become an essential part of everyday living of every households and commercial businesses at large (Bernetein and Griffin. 2006).

Fatai (2014) argues that energy has an essential role of demand and supply side in the economy. He explains that "on the demand side, energy is one of the products a consumer decides to buy to maximize his or her utility. On the supply side, electricity is a key factor of production in addition to capital, labour and material." It can be argued that many studies are in support of energy or electricity consumption being an important factor for economic growth and it is also considered that energy policies that are meant for conversation might affect real growth. Stern (2010) also supports the importance of energy to growth as a reduction in the availability of energy will impose economic growth whereas sufficient supply of energy encourages economic growth. The economic behaviour is in most cases based on how the energy services perform. If there is a decrease in electricity supply, production is affected negatively and directly affect the income level of the country from ordinary citizens to industries at large.

Many studies that have been conducted in some African countries resulted to a unidirectional causality from economic growth to electricity consumption. A study conducted in Malawi by Jumbe (2004) found a unidirectional causality running non-agricultural GDP to electricity consumption and bi-directional causality between electricity consumption and growth. A unidirectional causality between non-agricultural and electricity countries simply implies that non-agricultural countries are less dependent on electricity consumption. Fatai (2014) found that Southern Africa sub-region is likely to be dependent on electricity consumption as growth is driven by the consumption of electricity especially when it comes to the production process.

While the view is that electricity consumption is an essential factor of the production process that drives economic growth, other studies are of a different view. Lee and Chang (2008) for example, touch on the "Solow-Swan" growth model which states that energy is not directly linked with the production function. That being the case, many studies have proven to be in favour of energy being a crucial part of the production function and economic growth (Jumbe, 2004; Stern, 2010; Odhiambo, 2010).

Lee and Chang (2008) conducted a study on "energy consumption and economic growth in Asian economies" and found that energy is directly linked to production as an important factor. Their results found that energy consumption to Granger Cause GDP in the long run, implying that high energy consumption leads to high growth in GDP but not the other way round. Furthermore, any change in the consumption of energy will directly cause a change in the economic activity, this can be supported by viewing the case of South Africa whereby energy crises that were experienced during the year 2008 affected the country's economic activities negatively. It is further concluded that continuous consumption of energy results to continuous rise in output.

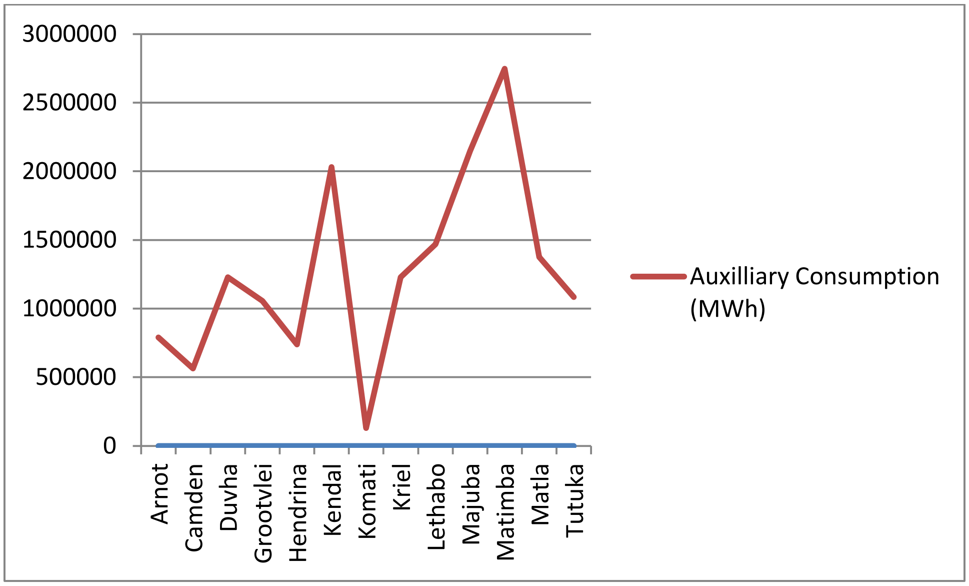
Jumbe (2004) on the other hand finds that an increase in GDP may cause an increase in the consumption of electricity. Jumbe argues that consumption of commercial energy, in this case being electricity consumption, signifies the economic status of a country taking into account the fact that it enhances productivity. Even though an increase in GDP may cause an increase in electricity consumption, it can be argued that any economy that is energy dependent, if ever there is a shortage of energy it will negatively affect the performance of such an economy.

In his study of "Cointegration and causality between electricity consumption and GDP," Jumbe (2004) finds that electricity consumption is cointegrated with GDP and NGDP. The results further show that there is a bi-directional causality between electricity consumption and GDP. It is also pointed out in the study that an increase in GDP will result to an increase in electricity consumption. In most cases, countries that are dominated by the agricultural sector are less dependent on electricity, hence in this case change in GDP results to a change in electricity consumption and not the other way round.

South Africa depends on coal for its electricity generation. Coal that is used for electricity generation is supplied by coal mines that utilize electricity for their production. As noted that South Africa is and industrialized country, just like countries such as Botswana, the country also depends on its mining sector for economic growth and development and in this case electricity consumption is vital in this industry.

Figure 2.3 Performance of coal-fired station in South Africa

The auxiliary electricity consumption, in Megawatt-hours (MWh) for each of Eskom's coal-fired stations for the year 2010-2011



Source: Eskom 2015

Figure 2.3 shows the performance of coal-fired station in South Africa with result to each station's electricity consumption. The figure focuses on 13 coal-fired stations namely, Arnot,Cam den,Duvha, Grootvlei, Hendrina, Kendal, Komati,Kriel, Lethabo, Majuba, Matimba, Matla and Tutuk. From the period of 2010 to 2011 Majuba station had the highest consumption of electricity, whereas Komati station recorded a low consumption of electricity. The reason for differences in electricity consumption can be due to the different in size of every station and the load of production that each station carries. As each station consumes electricity according to its required level of production, it will result to enough coal being produced for electricity generation.

2.2.1 Understanding the Coal industry of South Africa.

It has been assumed that the coal industry or the coal used in electricity generation has a direct impact to load shedding and is one of the determinants to the problem of load shedding. The quality of coal supplied and used for the generation of electricity affects the consumption of the electricity. This section of the study takes a look into the coal industry of South Africa in order to understand the significance of coal supply to electricity generation which contributes towards load shedding.

In terms of coal production, South Africa is regarded to be a low cost producer of coal with the largest coal terminal which is also in a world competitive scale of coal exports and production. Not only does the country play a role of producing and exporting role, it also plays a major role of consumption with respect to electricity production. The coal industry plays a vital role in the economy of South Africa as pointed out by Eberhard (2011), stating that coal accounts for 70% of primary energy consumption, 93% of electricity generation and 20% of petroleum liquid fuels.

Internationally, coal is currently the most widely used for primary fuel, accounting for approximately 36% of the world's electricity production. This situation is likely to remain until at least 2020 given the rate of new innovations. Coal has traditionally dominated the energy supply sector in South Africa, dating to 1880s with coal supply transactions between the Vereeniging and the diamond fields of Kimberly. Currently, coal supply provides for about 77% of South Africa's energy needs. Due to lack of more energy sources, the use of coal is expected to take place for the next decade (Eberhard, 2011).

In terms of coal of coal production, South Africa is one of the largest coal producers in the world ranking at fifth place. Also. The national electricity supplier, Eskom, ranks 7th place in the world when it comes to electricity generation. On average the country produces over 22 million tons of coal of which 25% is exported to the international market, most of the coal produced in the country is supplied to local industries as 53% accounts for electricity generation. It is evident that the coal industry of South Africa plays a vital role in contributing towards economic growth as far as electricity generation in concerned (Eberhard, 2011).

Producing electricity from coal starts when the coal is pulverized in huge mills into a fine powder before it is blown into huge kettles, called boilers. Due to the heat in the boiler, the coal particles combust and burn to generate heat to turn water into steam. The steam from the boilers is used to turn the blades of a giant fan or propeller, called a turbine. The turbine turns a coil made of copper wire (the rotor) inside a magnet (the stator). Together they make up the generator. The generator produces an electric current, which is sent to the homes and factories of consumers via power lines (Moyer, 2010).

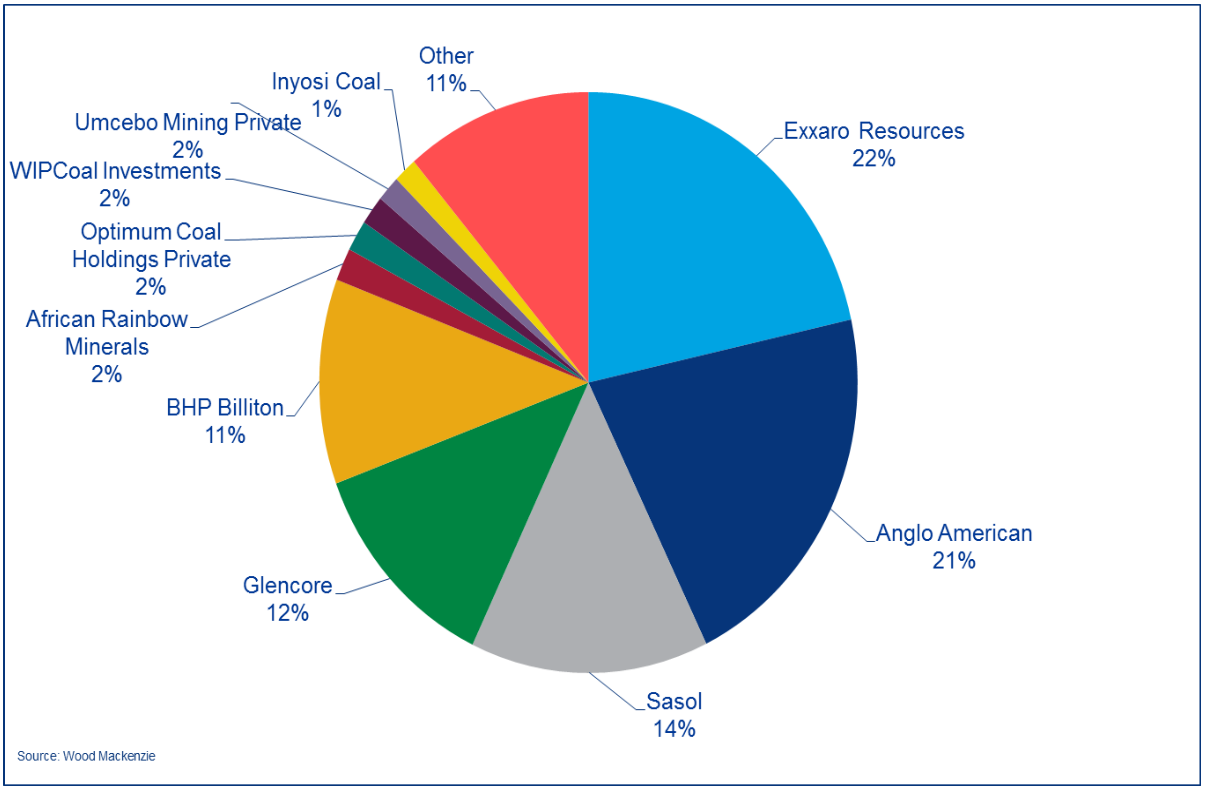
With the current increase in prices of coal, Eskom mostly finds its self in a situation of being supplied with low quality coal. With regards to the coal industry of South Africa, there are two major fields, namely Waterberg and Mpumalanga basin. These two major coal fields form part of the 11 coal fields in the country. Waterberg has large reserves in the country with a large contribution towards the economic growth and electricity generation, on the other hand, Mpumalanga basin accounts for 80% of South Africa's coal production with an expectation of 30 years of forecasted economic life of coal production and reserves. Coal requirements by Eskom are subjected by contracts. Such contracts include cost plus contracts, fixed capital contracts and short/medium term contracts. Cost plus contracts are those in which Eskom has a hand of capital contribution and all coal reserves are of Eskom's use only. Fixed priced contracts are those whereby coal is sold to Eskom on the bases of the contract and prices in this case are pre-determined. Coal reserves are not dedicated to Eskom and in any case of any dissatisfaction by Eskom, the supplier can be held accountable and face penalties. Short/ medium term contracts have the same operational criteria as of the fixed priced contracts; these contracts are mostly rendered to small emerging mining companies (.Eberhard, 2011)

Table 2.2. Below is the list of companies supplying coal to Eskom:

1	Liketh Investments (Pty) Ltd
2	Umcebo Mining (Pty) Ltd
3	HCI Khusela Coal (Pty) Ltd
4	Sudor Coal (Pty) Ltd
5	Stuart Coal (Pty) Ltd
6	Exxaro Coal (Pty) Ltd
7	Keaton Mining (Pty) Ltd)
8	Kuyasa Mining (Pty) Ltd
9	Shanduka Coal (Pty) Ltd
10	Ntshovelo Mining Resources (Pty) Ltd
11	Just Coal CC
12	African Exploration Mining & Finance Corporation
13	Wescoal Mining (Pty) Ltd
14	Hlagisa Mining (Pty) Ltd
15	Perisat Investments (Pty) Ltd
16	Universal Coal Development (Pty) Ltd
17	Vunene
18	Optimum Coal Holdings
19	Iyanga
20	Lurco Coal
21	Anglo American Thermal Coal SA (Pty) Ltd
22	Anglo American Inyosi Coal
23	BECSA (BHP Billiton Energy Coal South Africa
24	BECSA
25	Optimum Coal Holdings
26	Anglo / Exxaro JV
27	Xstrata / African Rainbow Minerals JV

Source: New age 2015

Figure 2.4 Breakdown of coal production by company



Source: Wood Mackenzie: 2015

The coal industry of South Africa consist of 5 major companies that are dominant in the industry, namely, Anglo-American, Xstrata, Exxaro, BHP Billiton and Sasol. Figure 2.4 shows that 5 companies dominate the coal industry of South Africa. Exxaro is one companies that is dominating the industry with 22% of coal production followed by Anglo American at 21%, Sasol comes in at 14% followed by Glencore with 12% of coal production. Last on the coal production domination list is BHP Billiton which stands at 11% when it comes to coal production in South Africa.

Of all the 5 dominating companies in the coal industry of South Africa, all companies excluding Sasol, are the coal suppliers to the country's electricity supplier Eskom. Regardless that a national entity is one major coal user of coal, the coal industry of South Africa is controlled by private companies.

2.3 Conclusion

This sections of the study unpack the usage of electricity in South African and provided an overview of how electricity is utilized in South Africa, also looking into the coal industry of South Africa which is a direct link to electricity generation in South Africa.

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This chapter reviews studies conducted on the relationship between electricity consumption and economic growth taking into account electricity as a commercial energy that is highly involved in the production process. Theories of growth, consumption, investment and infrastructure are also reviewed to identity and better understand the impact of electricity consumption towards economic growth.

3.2. THEORETICAL REVIEW

Several studies have been conducted to better understand the concept of electricity consumption. Bekhet and Othman (2011) point out that as by economics theory, electricity consumption has and inverse relationship with tariffs or prices. This further contributes to the point that an increase in tariffs or price might have a negative impact towards the consumption of electricity, whereas a decrease in prices will result to an increase in the consumption of electricity. The process of demand involves consumers utilizing commodities to their maximum capabilities. Demand is influenced by factors such as price changes, taste and level of scarcity or availability which is relative to supply. Taking supply and demand into account with respect to energy or electricity consumption, the study at hand looks into the theory of elasticity.

3.2.1 Theory of Consumption

The prospect theory of consumption suggests that consumers are more interested in how much they consume and do not pay much attention to the value of their consumption. This suggests that consumption rate is influenced by the demand rate and whether supply can meet the demand (Hung and Wang, 2005). Comparing the theory to the consumption of electricity, consumers will use electricity even if electricity tariffs are hiked as electricity consumption will still be evident due to the fact that economic activities revolve around consumption of energy.

With regard to consumption growth theory, the rate at which consumption operates is influenced by the change in the pattern of consumption. Consumption development is influenced and determined by investment. Investment encourages new innovations and growth and with electricity consumption, new electricity innovation will have a direct impact towards the consumption for electricity. Innovation entails identifying and introducing new ideas, products and services to the market. Innovations enhances economic growth by increasing demand and consumption. The process of innovation is supported by labour productivity, finances and sufficient resource allocation (Gualerzi, 2011).

Anderson and Sedatole (2013) state that the relationship between production and consumption is caused by pricings. With respect to the production of electricity as part of the modern cost theory, the price of production determine the output which also determines the level of consumption for electricity consumption and also prices charged by the suppler to consumers for consuming electricity, which in turn can contradict the statement by (Hung and Wang, 2005).

3.2.2 Harrod Domer growth model

The Harrod Domer model state that savings and capital output ratio contribute towards the growth of the economy. The Harod Domer model was developed by Roy Harrod in 1939 and further developed by Evsey Domar in 1946. One of the model's characteristics is the consistent study of long-run problems with the usual short-run tool. With regards to the point of saving and capital output ration, savings leads to an increase of money in circulation which can be used by household and firms to exercise their market right without damaging their buying power. In the case of Eskom and the problem of load shedding, financial instability by the organisation contributes towards the problem of load shedding. This will have a negative impact towards Eskom. An increase in savings can lead to increase in productivity as those savings will be used towards production if needed.

Capital output ratio looks at the availability of natural resources in a country which contributes towards productivity. An increase in capital output ratio will result to a decrease in productivity which will result to a decrease in economic growth as this is an indication that the productivity is inefficient. This can be related to coal production used for electricity generation. Inefficient productivity of coal and supply has a direct genitive impact towards the generation of electricity which will in the end result to the problem of load shedding.

A short coming of the Harrod Domer Model is that is does not take labour force into consideration. The model only takes into account the capital output ratio which is in relation to investments and savings. The role played by investment in the economy is important as it accounts to the rate of productivity that takes place within the country. However, the role played by the labour force in the production phase should not be ignored as an increase in labour force will result to an increase in productivity.

3.2.3 Infrastructure Development Theory.

Infrastructure development contributes positively towards the economic activities of a country. Lack of infrastructure and its development have a direct impact towards economic growth and development. Public Investment in can help reduce or deal with issues that contribute negatively towards growth. Agénor (2006) argues that infrastructure services promote growth through various factors that contribute towards the rate productivity**.** Agénor (2006) further states that, reducing the use of woods and charcoal as a substitute to electricity will help improve hygiene and health, thus the importance of electricity infrastructure development.

The theory of Infrastructure development indicates that infrastructure plays a vital role towards the growth of the economy in the sense of its impact in advancing health services which take into account the livelihoods and health of workers, as healthy workers leads to an increase in economic activity. Infrastructure resources can be classified as public goods, the use of infrastructure resources in the end, impacts the lives of the public at large. With infrastructure resources being classified as public goods, government intervention is essential with respect to the role played by the government towards its communities. The intervention by the state is with respect to infrastructure development, as it ensures that there is sufficient allocation of resources and making sure that public demands are met (Frischmann, 2006).

Infrastructure development ensures that economic activities are not interrupted. With development taking place there is sufficient productivity taking place without any difficulties. Taking load shedding into account, infrastructure development for electricity generation will result to sufficient supply of electricity, which will bridge the gap of demand and supply

3.2.4 Elasticity

With respect to elasticity, the study looks at income elasticity representing the percentage change in demand for a product or commodity given a percentage change in income (Ramskov and

Munksgaard, 2001). With elasticity a percentage change in income of one individual will cause a chance to his or her demand for given goods because there is more money available to be spent in order to satisfy a need or a want of an individual. The same concept applies to a decrease in income which will result to a decrease in demand for a given good.

However, due to the role that electricity plays in every households, commercial business and industries, Bekhet and Othman (2011) find that electricity consumption is not that responsive to the change in income due to electricity being a necessity. This is also in line with the result of Ramskov and Munksgaard (2001) that a reduction in income will not reduce the consumption of electricity because it is not a luxury but a necessity. However, it can be argued that an increase in income can lead to an increase in the consumption for electricity, taking into account that households and businesses can find themselves in a position where they can afford to buy extra goods that might be energy intensive thus resulting to an increase in electricity consumption.

Since it has been identified in many studies that electricity consumption is not that sensitive or responsive to price changes and income changes, the study further looks into the own-price elasticity theory, whereby a percentage change in demand results to a percentage change in price, as to a point whereby an increase in demand for a given good is experienced through an increase in price. As argued that an increase in price of electricity will not have much of an effect to electricity consumption, the own-price elasticity can be identified to best fit the concept of electricity consumption with respect to price changes. Bohi and Zimmerman (1984) pointed that during the 1970s the price shock to electricity had very little effect to the demand for electricity and its consumption. Even though there might be a shock to prices of electricity with very little effect to its demand and consumption, not many ordinary citizens are in most cases affected by the electricity price, taking into consideration those who are victims of socio economic problems.

Strengers (2012) argues that supply-demand siloes are used to manage electricity systems. In this case everyone has a role to play whereby the role of a suppler is to ensure that there is a supply of given resources or services, and the role of a consumer is to utilise the given resource or service according to his or her means of living. Strengers (2012) further argues that when taking electricity into account, an increase in the demand for electricity results to a problematic context of the supply and demand relationship, especially when supply cannot meet the increasing demand.

Chen and Chen (2006) conducted a study on Asian countries regarding the relationship between GDP and electricity consumption. The study highlighted four types of causal relationship that are found to exist between electricity consumption and economic growth, and they are listed below.

1. Unidirectional causality running from electricity consumption to economic growth

Fatati (2014) found a stable long run equilibrium between energy consumption and economic growth of which resulted to and unidirectional causality from energy consumption, meaning that an increase in the consumption of energy or electricity will result to economic growth while a reduction in the consumption of electricity will have a negative impact towards economic growth. These findings support the hypothesis that electricity consumption having a positive impact towards economic growth which can be directed to support the hypothesis of the study at hand of a direct negative relationship between load shedding and economic growth. With load shedding, there is a decrease in electricity consumption which will result to a negative impact towards economic growth.

2. Unidirectional causality running from economic growth to electricity consumption

According to Chen et al. (2007), unidirectional causality running from economic growth to electricity consumption suggests that "*the policy of conserving electricity consumption may be implemented with little or no adverse effect on economic growth, such as in a less energy dependent economy*". The Unidirectional causality running from economic growth to electricity consumption concept is seen to be faced by countries like Malawi which is a dominated by the agricultural sector. In this case the view of load shedding or electricity supply interruptions has very little impacts towards the growth of the economy. Agricultural sector depended countries, depend less on electricity consumption, the use of electricity is mainly in the tertiary or commercial sector.

3. Bidirectional causal relationship

A bidirectional causal relation between electricity consumption and economic growth sees these two factors as being joint together as there is not situation of one depending on the other like in the case of having unidirectional relationship running from electricity consumption to economic growth or the other way round. In this case, both electricity consumption and economic growth are jointly determined and affected all at the same time (Chen et al., 2007). In his study done on

Malawi, Jumbe found join determined relationship between Kwh (electricity consumption) and GDP. This entails that the rate of growth for one country's economy is determined at the same time as the consumption level of electricity. One can debate that a bidirectional causal relationship can help measure and determine growth accordingly taking into account electricity consumption.

4. The absence of causal relationship

The absence of causal relationship between economic growth and electricity consumption means that there is no correlation between electricity consumption and economic growth. Policies and measures put to place to enhance the rate of or the availability of electricity have no effect towards the growth of one country's economy. This happens in countries that have no or little dependence towards the consumption of electricity or countries that are not electricity intensive. In reality it is rather difficult to find a situation of absence of causal relationship because almost every part of the world relays on electricity to enhance and improve the production process be it countries that are not dependent on electricity or countries that are dependent on electricity, somewhere somehow electricity places its part and contributes towards production and everyday lifestyles of ordinary households. However this does not eliminate the possibility of no causality between electrify consumption and economic growth.

3.3 EMPIRICAL REVIEW

The chapter further looks into other studies that have been conducted in relation to the topic of the study and their conclusions. A review of the African countries which includes, Botswana and Malawi, with a review of other countries like Pakistan and India have been conducted in this section to better understand the significance of electricity in other countries with comparison to the significance of electricity generation and usage in South Africa.

3.3.1 An African overview

The African continent proves to be developed overtime. However, some parts of the African continent do not have high consumption of electricity due to lack of infrastructure development and investment. Using cointegration and Granger Causality tests, Rufael (2006) found many factors can contribute towards the relationship between economic growth and the consumption of electricity. It can be suggested that the reason to that leads to such findings of many factors contributing towards electricity consumption can be due to the fact that within the continent the growth rate differs from one country to another as other countries are more developed than others, taking other factors into account. The different growth rate in different countries can suggest that growth has a direct impact towards the consumption of electricity.

In the study for Asian developing countries, for example Asafu-Adjare (2000) found that countries that depend more on the consumption of electricity are likely to be affected by a shock (a change) in the production or generation of electricity. This in the same case for South Africa and the problem of load shedding. Electricity shock affects production which will affect the local and international market in terms of trade. Given the fact that some African countries are more developed than others, the consumption of electricity is not at its ultimate peak (Rufael-Wolde, 2006).

Developing countries in the African continent are the ones that are in most cases affected negatively in terms of development whenever there is a shortage in electricity supply and consumption. However, it should also be pointed out that the demand for electricity consumption in developing countries can always be identified by the employment rate, as the African continent has in many decades experienced high unemployment rate which also has a direct impact towards economic growth. The study directs its attention to some of the African countries in terms of electricity consumption as listed below. The aim of an African overview is to understand how electricity impact other African countries with respect to their economies.

3.3.1.1 A Malawian study

Countries like Malawi are not energy intensive due to the fact that they are dominated by the agricultural sector as seen in many developing countries. The agricultural sector does not use much electricity to enhance its production, but mostly depends on resources that are less energy intensive. Therefore, countries like Malawi do not really depend on electricity as electricity consumption has little impact towards their economic growth.

Jumbe (2004) found that electricity consumption cointegrate with GDP and NGDP but not with AGDP with a bi-directional causality between electricity consumption and economic growth. Furthermore, the ECM model showed less dependence of the country’s economy to the consumption of electricity as it is an agricultural sector dominated economy which is not highly dependent on electricity consumption.

Shifting the focus from Malawi to South Africa, the country being an energy dependent country, it largely depends on coal reserves for its electricity generation. Coal is regarded as on the most important elements of electricity generation. With that's being said, South Africa is one of the lowest coal producers in the world due to the fact that most of the coal produced in the country is of low quality (Nkomo, 2005). The quality and availability of people determine the generation process of electricity.

3.3.1.2 A Botswana Study

A study was carried out to investigate the relationship between the consumption of electricity and real gross domestic product in Botswana (Adebola, 2011). The results show that as the largest producer of diamonds the country is a highly energy dependent country of which most of its electricity supply is imported from South Africa.

The mining industry of Botswana has proven to be the driving force of the country's economic growth, hence electricity consumption is an essential part of the country's production. Adebola (2011) further suggests that capital formation can have adequate impact on the economy if there is adequate electricity supply in the economy with further suggestion that if there is an improvement in electricity there might be an improvement to generating income.

Although Botswana depends on electricity consumption to drive the economy, the electricity generation of the country has been declining over the years as it fell from 546.6519 KWh per capita in 2001 to 308.674 Kwh per capita in 2008 (Adebola, 2011). The case of the declining generation of electricity seems to be of the same reasons as in the case of South Africa which involves poor maintenance of power station while on the other side there is an increase in the consumption of electricity.

3.3.2 A Pakistan study

A study of Pakistan on the causal relationship between Electricity Consumption and GDP concluded that the country needs energy policies to improve the electricity sector, seeing that the country is an electricity deficient country (Jebran, 2014). Many giant companies pulled out from the country's economic activity due to insufficient amount of electricity and the high cost of using other sources of energy for production, there more companies pull out from one country's economic activities the economic performance of a country is due to be impacted negatively .

Results obtained from the study suggest that about 14% of the country's economic growth is the result of electricity consumption. For this reason, enhancing the electricity sector is essential in order to enhance economic growth. The country's power capacity is around 21000 MW of electricity generation; the country has been one of those countries that had limited resources to invest in its electricity sector. As a developing country, the country needs electricity enhancement to contribute positively towards its economic growth.

According to Shahbaz and Feridun (2011), in the case of Pakistan, underdeveloped energy infrastructure has a negative impact towards the growth of the economy. Using the Autoregressive Distributed Lag (ARDL) bounds testing, Shahbaz and Feridun found that electricity consumption and economic growth have a long run equilibrium relationship and the direction the relationship that runs from growth to electricity consumption, suggesting that in the case of Pakistan, economic growth leads to an increase in electricity consumption. The Results of Shahbaz and Feridun (2011) supports those of Ghosh (2002), Soytas and Sari (2003) and Halicioglu (2007), who found that growth leads to an increase in electricity consumption.

3.3.3 Indian Study

In the case of India as a country with high population growth rate that accounts for one-sixth of the world's population, it is to expect that there is high demand for electricity (Ghosh, 2002). In 2014 India's population growth accounted for 1 287 395 209 (United Nations department of Economic social Affairs: Population Division, 2015). This indicates that over 1 billion of India's population demand electricity or depend on electricity consumption for their day to day activities. In the study to investigate the existence if granger causality between economic growth and electricity consumption, Ghosh (2002) found that an increase in income will result to an increase in the consumption of electricity, this suggesting that, growth causes an increase in electricity consumption. From such findings, one can suggest that high population growth rate can result to high employment rate given that the economic stability of a country can result to an increase in income which will then result to increase consumption.

According to economic theory, an increase in buying power results to an increase in demand which leads to an increase in consumption resulting to an increase in the consumption for electricity. With respect to increasing population, it has been indicated that households are more dependent on the consumption of electricity and not only in households but in other economic sectors that contribute positively towards the growth of India's economy, this suggesting that economic growth as a result of increasing market participation caused by increasing population, enhances the consumption of electricity in India.

3.4 Conclusion

This chapter focused on two factors being the theoretical literature and empirical review on the study of electricity consumption and its significance to economic growth. The importance of electricity was highlighted throughout and the significance of electricity was indicated in the chapter buy studies conducted in other countries as compared to South Africa taking into account economic growth and the relationship between production and electricity consumption. From the this chapter one can identify the impact and the importance electricity has on economic growth and how will the economy be affected by load shedding

CHAPTER FOUR

Research Methodology

4.1 Introduction

In this chapter, the methodology used for this study explained. The chapter looks into the adopted methodology and further defines the variables applicable to South Africa and models used for data analysis of the study and further provides an outline of the chapter.

4.2 Model specification and definition of variables

The analyses of the impact that load shedding has on economic growth is regarded to have a negative impact towards growth, however the study aims to analyse and identify just how crucial load shedding is to growth. The study adopts the methodology of Bekhet and Othman (2011), on the study they conducted assessing the elasticities of electricity consumption for rural and urban areas in Malaysia. The methodology is based on the consumption of energy whereby it is expressed as a function of GDP, electricity tariff, gas price and population in rural and urban areas. However the methodology is modified in this study to include other variables or factors that are relevant to the study at hand.

Study variables: GDP, ELECTRICTY CONSUMPTION, ELECTRICITY PRICE, INCOME AND POPULATION.

Before the modification, the function of electricity consumption is expressed in Equation [1]

$$EC_t = f\ (Y_t, Pe_t, Pg_t, R_t, U_t) \qquad [1]$$

Where $EC, Y, Pe, Pg, R\ and\ U$ represent electricity consumption, GDP, electricity price, gas price, population respectively as according to Bekhet and Othman (2011). The modified equation for the study identifies GDP as an independent variable with electricity consumption as a proxy. Furthermore the model includes $I(income)$ as an extra variable is expressed in Equation [2]

$$Y = f\ (EC_t, Pe_t, P_t, I_t, U_t) \qquad [2]$$

The mathematical model of the equation is expressed in Equation [3] and further transformed be a liner as shown in Equation [4]

$$Y_t = {EC_t}^{\beta 1}\ {Pe_t}^{\beta 2}\ {P_t}^{-\beta 3}\ I^{\beta 4}\ {U_t}^{\beta 5} \qquad [3]$$

$$Y_t = \beta_0 + \beta_1 lec_t - \beta_2 lpe_t + \beta_3 lp_t + \beta_4 lI + e_t \qquad [4]$$

All variables of the model are transformed into their natural logarithms in order to simplify certain arithmetic calculations (Michener, 2003). Economic growth is regarded as a depended variable, which can be explained by the explanatory variables; electricity price, electricity consumption, population and income which are defined in the study as KWHP, KWHCONS, POP and INCOME respectively.

It is with great assumption that all these variables contribute towards load shedding and economic growth. An increase in population, results to an increasing in electricity consumption, and as by the demand rule, an increase in demand results to an increasing in consumption which will automatically results to an increase in electricity prices. An increase in Income insight consumers to consume more due to an increase in their buying power. With that being said, increase in spending has a positive impact towards economic growth however when it comes to electricity consumption as in the case of south Africa, it lead to a point whereby supply fails to meet demand.

It is therefore that the apriori expectation of the results of the study will be to prove that load shedding has a negative impact towards economic growth. An insight of what contributes to load shedding is identified by the variables used in the study.

Analysis of the study at hand involves the process of testing for stationarity by making use of the Engle-Granger test which also will be used to examine cointegration to eliminate the possibility of spurious regression in a time series model. Furthermore, stability tests were conducted also taking into account the error correction model to measure the speed at which prior deviations from equilibrium are corrected (Best, 2003).

4.3 Data sources

The study uses an annual data compiled from the South African Reserve Bank for all variables used in the study, excluding data for population which was compiled from the World Bank (WB). The study focuses on the period of 30 years which ranges from 1984 to 2014.

4.4 Research Techniques

For estimation purposes, the study uses the Engle Granger model approach for analyses purposes as it useful when estimating cointegration amongst variables, which indicates a long run relationship between variable.

4.4.1 Regression analysis

Regression analysis is a process of estimating a relationship between variables. The variables used for estimation are held to be dependent variable and the independent variable(s). The whole process is to identify just how much impact does the independent variable(s) have towards the independent variable(s). Again, it determines whether a certain percentage change of the independent variables result to any change in the depended variable or if there is not influence or impact whatsoever.

$$Y=a+BX+e.$$

The above formula represents the presentation of the regression model where:

Y = dependent variable,

a =slope of the model

BX = model coefficients

e = represents possible omitted variables from the model

4.4.2 Stationarity test

Testing for stationarity is essential because the standard assumption for asymptotic analytic can prove not to be valid if stationarity is to be tested. Furthermore, stationarity identifies the existence of spurious regression as in most cases two variables are found to be trending over time. According to Brooks (2008), stationarity can be reached or achieved by differencing the variables

$$Y_t = \alpha + \emptyset Y_{t-1} + e_1$$

The above equation represents model AR (1). The above model represents the dependent variables as the explanatory variables. The used explanatory variables are considered to be of one legged periods. Autocorrelation and nonstationarity are identified by $\emptyset$ and its value. Whenever autocorrelation is closer to one, it means that the variable has a long run memory and along with a trend behaviour, which indicates nonstationarity. Within the series, the existence of unit root can be identified by having a value of 1 in the AR model. However, stationarity is identified when $\emptyset < 1$, in this case the series will also have no long run memory. If there is nonstationarity, the concept of differencing is introduced to try and eliminate nonstationarity to stationarity (Koop, 2009).

To test for stationarity, ADF and PP test techniques are used to test for unit root of the series. Both test techniques have the same null hypothesis as they both test for stationarity with a null hypothesis that read as "series has a unit root" and the alternative of "no unit root" which indicates stationarity.

4.4.3 Test of Augmented Dickey-fuller (ADF)

The common use of ADF test also known as the Augmented Dickey-Fuller test, as named after its developers, is used to test for unit root. Using the ADF test, is to test the null hypothesis of ARIMA process and is examined against the alternative null hypothesis of stationary ARIMA (Chueng and Lai, 1995).

The null hypothesis of the test is represented as Ho: θ=0 whereas H1: θ<1 represents the alternative null hypothesis of stationarity. The null hypothesis indicates that there is no existence of unit root in the series, the test allows to test the behavioural trends and slot to correct serial correlation.

The ADF test consist of the following regression estimation

$$\Delta Y_t = a_1 + a_{2t} + aY_{i-1} + \sum_{j=1}^{k-1} \beta_J \Delta x_{t-1} + U_t$$

u_t Represent the white noise innovation which stands for all possible variables that might have been omitted, (Cheung and Lai, 1995).

4.4.4 Test of Phillips Perron

Phillips Perron test as named after its developers is used to test for unit root, the test does not differ from the ADF test of unit root. Both tests address the problem of nonstationarity of variables, however there has been arguments that the test is not as good as the ADF test (Davidson and Mackinnon, 2004). The test statistics can be used to modify the Augmented Dickey-fuller test for the serial correlation and correct heteroscedasticity (Phillips and Perron, 1988)

The PP test consist of the following regression estimation

$$\Delta Y_{i=}\alpha + Py_{i-1} + \alpha Y_{t-1} + \varepsilon_i$$

The advantage the PP test have over the ADF test is that handling the problem of heteroscedasticity.

4.4.5 Test of Cointegration

The test takes into account the problem of spurious regression. When testing for cointegration, the spurious regression results can be eliminated. Cointegration test holds to analyse if two or more variables have a long run relationship. With this test, accurate economic decisions can be used with respect to the result from testing for cointegration. Cointegration eliminates the existence of stochastic trends and stationarity takes place when variables are integrated in the same order (Koop, 2009)

Stationarity of regression errors can be fixed by the existence of cointegration. To test for cointegration, The Engle-Granger and the Johansen techniques are usually used to test for cointegration within the model, and this study will use the Engle-Granger test for cointegration which adopts the style of ADF testing, as it is based on unit root testing.

4.4.6 Test of Granger-Causality

The Granger-Causality test is used to test if one time series has an impact towards another, this implies that, time series X can cause a change in time series B. However, the limitations of Granger Causality are that the test can provide results that might be misleading if the relationship test involves more than three variables. With Granger-Causality, the one time series determined to granger cause another if it can be used to forecast another. The two assumptions of Granger-Causality are based on the principles of "the cause happens prior to its effect" and "the cause has unique information about the future values of its effect" (Diks and Panchenko, 2006).

4.4.7 Test of Diagnostics

Diagnostics checks are performed in order to ensure that the specification of the model is correct. The Adequacy of the model can be identified through diagnostic check, hence the relevance and importance of the tests in this study. Testing will provide information to conclude that the model if best to use for forecasting purposes and estimations. Diagnostic check include properties which are explained below.

4.4.7.1 Normality

Normal distribution of residual is tested by performing the normality test, the test enables one to identify if the residuals are normally distributed or not. If the results of the normality test holds to have a zero mean and a variance with a constant value, then normality can be concluded, the result should be in line with the assumptions of Classical Liner Regression (Koop, 2009). Furthermore the test helps identify the problem of misspecification as the regression residuals are evaluated.

4.4.7.2 Heteroscedasticity

According to the OLS assumption, the presence of homoscedasticity is identified by a constant variance, however if the is no constants variance then there a presence of heteroscedastic, this means that, on of the assumptions of OLS have been violated. If the model series proves for misspecification, there can be a presence of heteroscedasticity as well as taking model series into measurement which might contain errors. When testing for the existence of a relationship amongst variables, the white heteroscedasticity test is introduced, with the null hypothesis that reads as "no heteroscedasticity'' against the alternative of heteroscedasticity. The study uses the white heteroscedasticity test to test for Heteroscedasticity.

4.4.7.3 Serial correlation

According to Anderson et al (2012), the measure of successive values over times stands for serial correlation. Serial correlation takes place when there is a correlation of error terms from different time series periods. However the shortcoming of serial correlation is that, it affects the efficiency of the OLS estimators. Causality cannot be identified by correlation as correlation is suggestive (Koop, 2009).

4.4.8 Model simulation

Simulation is a process of a model build up used for the study that will help study the studies effectives of the model and for forecasting purposes, the changes in variables of the study can be identified through the shock that take place with the model with the assumption that one variable change affects the whole model .

4.5 Conclusion

The aim of this chapter was to present the methodology used for the study as well as to introduce the estimating technique used to test for the residual unit root. The Augmented Dickey-Fuller and the Phillips Perron tests are performed to text for stationarity amongst variables. In order to test for a long ruin relationship amongst variables, a cointegration test is performed using both the Engle-Granger Cointegration test and the Johansen test of Cointergration. The adequacy and stability of the model is identified through diagnostics checking.

CHAPTER FIVE

INTERPRETATION OF THE RESULTS

5.1 Introduction

In this chapter, the study presents the results and the findings of the study. The study holds the null hypothesis of "Load shedding has a direct negative impact towards economic growth of South Africa," which is tested against the alternative hypothesis of "Load shedding does not have a direct negative impact towards economic growth of South Africa". Rejecting and accepting the null hypothesis of the study lies in the findings of the empirical evidence conducted for the study, also taking into account literature and theory.

As in most cases, a series can prove to hold the existence of unit root at their level form, and in order to eliminate the existence of unit root, the study uses the augmented Dickey Fuller (ADF) and the Philliphs-Perron (PP) tests series to test for stationarity and away with unit root within the series. Testing for unit root is the first procedure performed and after concluding the non-existence of unit root. Cointegration testing among variables is done to prove if variables are cointegrated in the long run by using the Engle Granger Cointegration tests. The Error Correction Model also known as the ECM is also computed to provide additional evidence to cointegration and the long run relationship of variables.

Diagnostics tests such as normality, serial correlation, Heteroskedasticity and stability follow in the third step of the analysis in order to rule if the results provided are of good use or do they hold no good use. Furthermore it is ideal to test for diagnostics in order to specify if the series is correctly specified. The fourth and the last step involves simulating the model used in the study which includes both the long run and the short run equations used in the study. After simulation is applied, one of the variables is shocked to test for model responsiveness to a shock.

Figure 3 and 4 give evidence of variables being non-stationary at their level form, however variables excluding POP prove to hold stationarity which is supported by a constant trend, also taking into account they are integrated at order one I(1)

Figure 5. 1 level form of variables in Logarithm

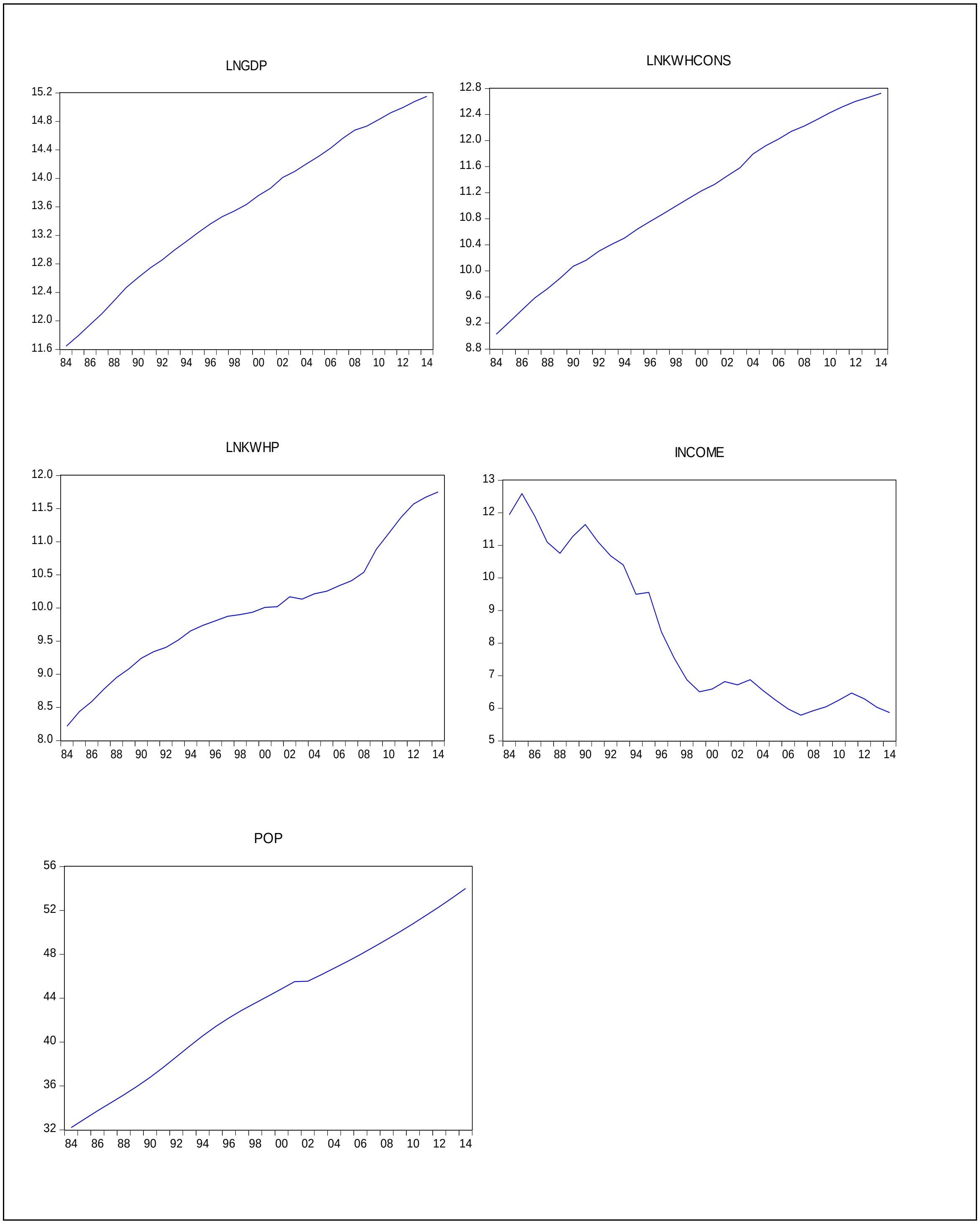


Figure 5.2 Difference form of Variables

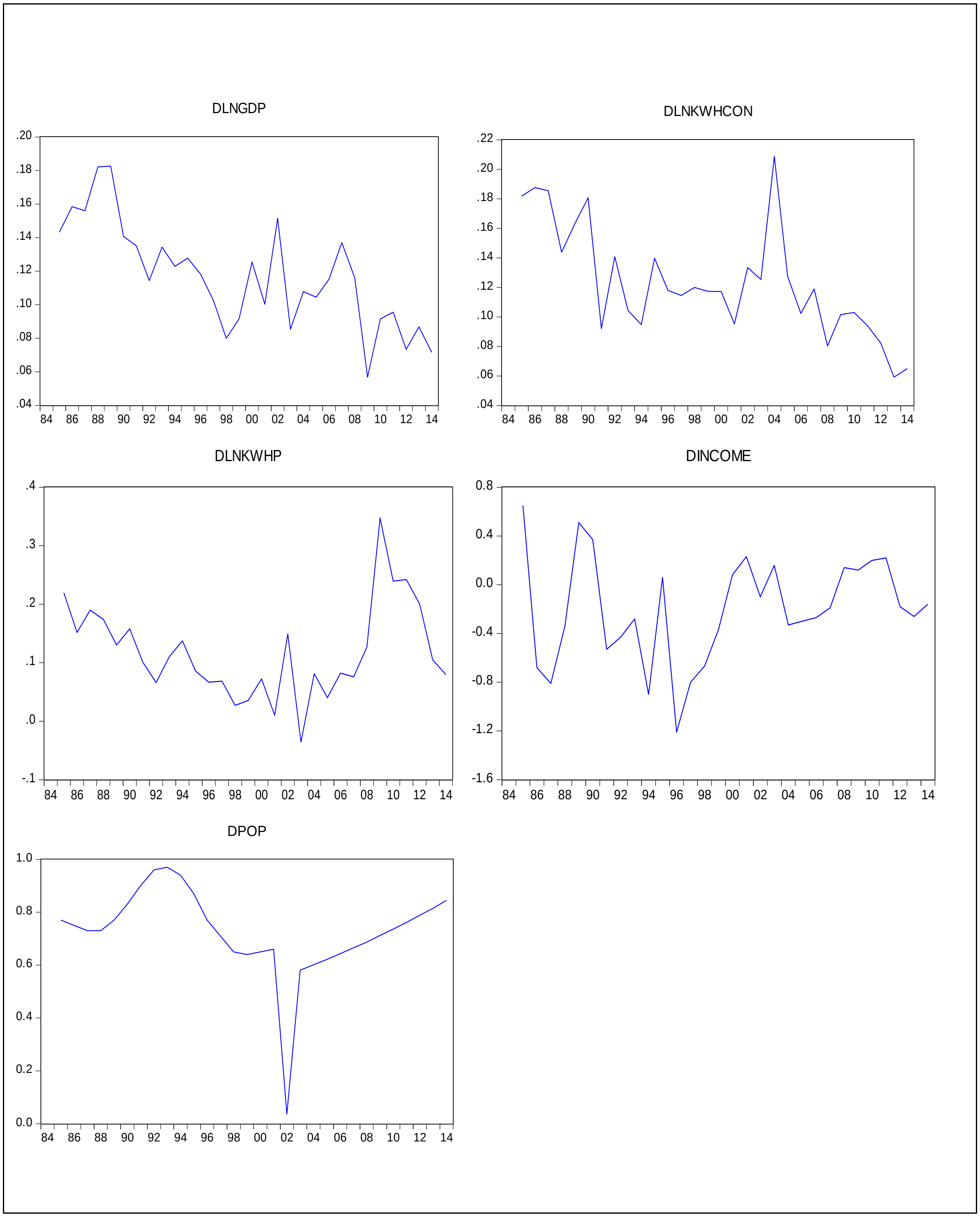


Figure 5.1 and figure 5.2 aims to identify the order of integration of variables used in the study. Figure 5.1 indicated that variables are not stationary at level s as there is no constant trend around the mean whereas with figure 5.2 variables prove to be stationary after being differenced once, which in indicated by the constant fluctuation of the trend line, therefore the order of integration of variables is I(1)

5.2 Stationarity tests

Table 5.2.1: Augmented Dickey-fuller test

Variable	MODEL	ADF		Lags	CONCLUSION
		Levels	1ST Difference		
LNGDP	Intercept	-6.257363***	-2.315628	3	**Stationary**
	Trend and intercept	-1.523307	-4.263576**		
	None	0.963385	-1.169091		
LNKWHCONS	Intercept	-4.897549***	-2.885496*	3	**Stationary**
	Trend and intercept	-1.317271	-4.116413**		
	None	1.133185	-1.507192		
LNKWHP	Intercept	0.116192	-3.051791**	3	**Stationary**
	Trend and intercept	-2.980085	-3.031992		
	None	-2.315465**	-1.233657		
INCOME	Intercept	-1.233342	-4.421756***	3	**Stationary**
	Trend and intercept	-1.462710	-4.764484***		
	None	-2.835389***	-3.608805***		
POP	Intercept	-0.596395	-2.761798*	3	**Stationary**
	Trend and intercept	-2.333685	-2.730669		
	None	2.061554	-0.211050		

* **Statistically significant at 1% level

** Statistically significant at 5% level

*Statistically significant at 10% level

H0: series has a unit root

H1: series have no unit root

Results interpretation

To identify the existence of unit root, the above table provides evidence of the ADF test. The results give evidence of the variables being stationary after they have been differenced at their first level.

At levels, for intercept the dependent variable LNGDP indicates significance at 1% and when differenced there is significance at 5% level for trend and intercept with the ADF values of -6.257363 and -4.263576 respectively. Variables LNKWHCONS, LNKWHP and INCOME indicate stationarity at levels for trend and intercept and none, with ADF values of -4.897549*** -2.315465** and -2.835389*** respectively which show the level of statistical significance of variables. However, all variables including POP indicate a strong statistically significance of variables at 1st difference. Stationarity at 1st difference is found at trend, trend and intercept and none respectively.

Variables are found to be integrated at order 1 I(1) as all variables indicate stationarity at 1st difference. Differencing of variables takes place if variables are not integrated at order I(0). In this case variables are integrated at order 0 I(0) and only POP is integrated at order I(0).

Therefore by taking into account the ADF test results, the study fails to accept the null hypothesis of unit, however the alternating null hypothesis is accepted which indicates that there is no unit root, meaning that variables are stationary.

Table 5.2.2: PP test

Variable	MODEL	PP		Lags	CONCLUSION
		Levels	1^{ST} Difference		
LNGDP	Intercept	-5.655755***	-1.256354	3	**Stationary**
	Trend and intercept	-1.532119	-4.263199**		
	None	8.900672	-1.256354		
LNKWHCONS	Intercept	-3.949176***	-2.778647*	3	**Stationary**
	Trend and intercept	-1.499478	-4.178364**		
	None	8.222011	-1.418027		
LNKWHP	Intercept	-0.280576	-3.049182**	3	**Stationary**
	Trend and intercept	-1.697276	-3.014779		
	None	5.030728	-1.761064*		
INCOME	Intercept	-1.216136	-4.421756***	3	**Stationary**
	Trend and intercept	-0.896600	-4.778718***		
	None	-2.610528**	-3.663300***		
POP	Intercept	-0.925331	-2.777658*	3	**Stationary**
	Trend and intercept	-1.624776	-2.764317		
	None	9.507436	-0.237531		

* **Statistically significant at 1% level

** Statistically significant at 5% level

*Statistically significant at 10% level

H0: series has a unit root

H1: series have no unit root

Results interpretation

As indicated in the previous chapter, the PP test does not differ from the ADF test, reason being that both test techniques are used to test for unit root. The null hypothesis of the PP test also states that there is unit root whereas the null hypothesis states that there is no unit root. However, it should be noted that the PP test can be used to adhere to the problem of serial correlation. If it is concluded that the null hypothesis of the test is rejected, this will mean that there is no unit root in the series. In this case the result of no unit root will not be contradicting to those of the ADF test.

Variables LNGDP, LNKWHCON and INCOME are stationary at levels with a critical values of -5.655755***, -3.949176***, -2.610528** respectively. LNKWHP and POP indicate stationarity at first difference as they are the two variables that are integrated at order I(0) with values of -3.049182 at 5 % level of significance for intercept and -1.761064 at 1% level of significance at none ,whereas POP is statistically significant at i-2.777658 at 1%.

The PP method indicated that variables are statistically significant. From the results above it is clearly indicated that not all variables are intergraded at their level form and they must be differenced to hold stationarity.

Therefore taking into account the provided results, the study fails to accept the null hypothesis of unit root, therefore the study accept the alternative null hypothesis of no unit root. In this case, the conclusion is that, variables are stationary either at levels or at 1st difference. It can be assumed that 1% decrease in the price of electricity will increase electricity consumption by 3.9% resulting to a positive impact towards economic growth. However it should be noted that an increase in electricity consumption does encourage load shedding. Therefore to an extent, load shedding is regarded as a shortfall of an increase in electricity consumption.

5.3 Cointegration test

Table 5.3. Engle-Granger cointegration test

Variable	Model	ADF Lags	ADF values
RES_COINT	Constant	**3**	-4.561057*
RES_COINT	Constant and trend	3	-5.300777*

* **Statistically significant at 1% level

** Statistically significant at 5% level

*Statistically significant at 10% level

H0: no cointegration (residuals are non-stationary)

H1: cointegration (residuals are stationary)

Constant and no trend

C (p) = $\phi_{\infty} + \phi_1 T^{-1} + \phi_2 T^{-2}$

1% C (p) =-4.9587-22.140(1/30)-37.29(1/900) =-5.739

5% C (p) = -4.1418-13.641(1/30)-21.16(1/900) =-4.620

10% C (p) = -4.1327-10.638(1/30)-5.48(1/900) =-4.493

Constant + trend

C (p) = $\phi_{\infty} + \phi_1 T^{-1} + \phi_2 T^{-2}$

1% C (p) =-5.2497-26.606(1/30)-49.56(1/900) =-6.192

5% C (p) = -4.7154-17.432(1/30)-16.50(1/900) =-5.3148

10% C (p) = -4.5345-13.654(1/30)-5.77(1/900) =-4.996

Taking the results of table 5.3 Engle-Granger cointegration into account, the study concludes that there is a long run relationship between variables of the study, which states that variables are cointegrated. Therefore the study fails to accept the null hypothesis of no cointegration amongst variables, but accepts the alternative null hypothesis which supports the existence of cointegration. The results show that significance is at 10% for constant along with constant and trend.

5.4 Long run model/regression analysis

Table 5.4 Long run model

Dependent Variable: LNGDP

Sample size: 1984 -2014

Observations: 31

Variable	**Coefficients**	**Std. Error**	**t-Statistic**	**Probability**
LNKWHCONS	0.686129	0.070226	9.770290	0.0000
LNKWHP	0.005212	0.061184	0.085193	0.9328
INCOME	-0.008589	0.014239	-0.603208	0.5516
POP	0.041020	0.020710	1.980669	0.0583
C	4.225888	0.309211	13.66667	0.0000

R-squared = 0.998948

Adjusted R-squared = 0.998786

Results and interpretation

As in table 5.4 LNKWHCONS can be used to statistically explain LNGDP in the long run. This is identified by the presence of a positive relationship between the dependent and the explanatory variable which is statistically significant, a negative relationship is found to exist between INCOME and the dependent variables whereas the rest of the variables have a statistically significant relationship with the dependent variable which is LNGDP. Therefore an assumption holds as a 1% change in income will cause LNGDP to change by 8% with respect to the result above. Furthermore 99% of R-squared suggests that the dependent variable can be explained by 99% of the explanatory variables. However it should be noted that to some extend the results of the long run model prove to be spurious.

5.5: Error Correction Model

Table 5.5 ECM

Dependent Variable: D(LNGDP) **Sample size:** 1984 2014 **Observations:** 28 after adjustments				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Probability**
D(LNKWHCON)	0.537603	0.159002	3.381100	0.0028
D(LNKWHCON(-2))	0.245871	0.153059	1.606381	0.1231
D(LNKWHP)	-0.035387	0.054858	-0.645059	0.5259
D(POP(-2))	0.080367	0.028862	2.784533	0.0111
D(INCOME)	0.010829	0.011261	0.961659	0.3472
ECT(-1)	-0.317664	0.145262	-2.186842	0.0402
R-squared = 0.619548 **Adjusted R-squared = 0.510847**				

Result interpretation

The importance of the ECM is to analyse long run equilibrium relationship between variables, it is used when variables show evidence of cointegration. The short and long run effect of one series to another can be identified by putting the ECM to place. The speed of adjustment can also be estimated by analyses of the ECM.

Table 4.5 indicates that the independent variable LNKWHCON and the dependent variable LNGDP have a statistically positive significant. However a negative relationship is indicated by LNKWHP as an explanatory variable, an assumption is that as 1% change in LNKWHP will result to a decrease in LNGDP by -0.03% when taking the above results into account.

INCOME indicates a positive relationship with the dependent variable. However it should be noted that the relationship between the explanatory variable and the dependent variable is insignificant.

The error correction proves to be significant, indicating 32% of speed of adjustment. The model further proves to be of good fit, indicated by 61% of significance.

5.6 Granger Causality Test

Table 5.6.1: Granger Causality (LNGDP: LNKWHCONS)

Null Hypothesis:	Obs	F-Statistic	Prob.
LNKWHCONS does not Granger Cause LNGDP	29	4.74300	0.0184**
LNGDP does not Granger Cause LNKWHCONS		0.13657	0.8730

Table 5.6.2: Granger Causality (LNGDP: LNKWHP)

Null Hypothesis:	Obs	F-Statistic	Prob.
LNKWHP does not Granger Cause LNGDP	29	0.54256	0.5882
LNGDP does not Granger Cause LNKWHP		1.00077	0.3824

Table 5.6.3: Granger Causality (LNGDP: INCOME)

Null Hypothesis:	Obs	F-Statistic	Prob.
INCOME does not Granger Cause LNGDP	29	0.43293	0.6536
LNGDP does not Granger Cause INCOME		2.78709	0.0816

Table 5.6.4: Granger Causality (LNGDP: POP)

Null Hypothesis:	Obs	F-Statistic	Prob.
POP does not Granger Cause LNGDP	29	0.02035	0.9799
LNGDP does not Granger Cause POP		2.08090	0.1468

Table 5.6.5: Granger Causality (LNKWHP: LNKWHCONS)

Null Hypothesis	Obs	F-statistics	Prob
LNKWHP does not Granger Cause LNKWHCONS	29	1.84906	0.1791
LNKWHCONS does not Granger Cause LNKWHP		2.44972	0.1076

Table 5.6.6: Granger Causality (INCOME: LNKWHCONS)

Null Hypothesis	Obs	F-statistics	Prob
INCOME does not Granger Cause LNKWHCONS	29	1.78184	0.1899
LNKWHCONS does not Granger Cause INCOME		0.47159	0.6297

Table 5.6.7: Granger Causality (POP: LNKWHCONS)

Null Hypothesis	Obs	F-statistics	Prob
POP does not Granger Cause LNKWHCONS	29	1.84918	0.1791
LNKWHCONS does not Granger Cause POP		1.78602	0.1892

Table 5.6.8: Granger Causality (INCOME: LNKWHP)

Null Hypothesis	Obs	F-statistics	Prob
INCOME does not Granger Cause LNKWHP	29	0.72767	0.4934
LNKWHP does not Granger Cause INCOME		1.82676	0.1826

Table 5.6.9: Granger Causality (POP: LNKWHP)

Null Hypothesis	Obs	F-statistics	Prob
POP does not Granger Cause LNKWHP	29	5.76043	0.0091**
LNKWHP does not Granger Cause POP		4.41380	0.0233**

Table 5.6.10: Granger Causality (POP: INCOME)

Null Hypothesis	Obs	F-statistics	Prob
POP does not Granger Cause INCOME	29	0.79147	0.4647
INCOME does not Granger Cause POP		5.05415	0.0147**

Results interpretation

The study includes the test for Granger Causality to further identify the impact of one variable to another. The above result indicates that causality exists between LNKWHCONS to LNGDP, LNGDP to INCOME, POP to LNKWHP, POP to LNKWHP and INCOME to PO, this suggesting that one time series can be used to forecast the other. However, the shortcoming of Granger Causality of giving misleading results if more than three variables are tested is taken into account, that being said, the existing causality can be supported by economic theory. The rest of the cases have a higher probability value of 5% level of significance, suggesting that there is no level of causality. Studies have been conducted for granger causality with evidence proving that economic growth granger causes electricity consumption (Aqeel and Butt, 2001), while on the other hand there are studies that show that electricity consumption granger causes growth, for example Chandran et al. (2010), Yuan et al. (2007) and Yoo (2005).

5.7: Diagnostics tests

Table 5.7 Diagnostics checking

Types of Tests	**Tests Null Hypothesis**	**T stat**	**P-value**	**Conclusion**
Test for serial correlation: Breusch-Godfrey	No serial correlation	0.589830	0.5643	accept null hypothesis
Test for Heteroskedasticity: White	No heteroskedasticity	0.380920	0.8829	accept null hypothesis
Normality test : Jarque-Bera	Residuals are normally distributed	2.026322	0.363068	accept null hypothesis

Testing for diagnostics helps identify if the model is good to be used for decisions making. As shown in table 5.7 the study performed the fowling diagnostics checks, serial correlation, Heteroskedasticity and normality test. These tests will help analyse the significance of the model. As indicated in the table above, all the diagnostics of the model check out, therefore the model can be used for decision making. Table 5.7 indicates the significance of the diagnostics which can be identified by the probability value, and if the value is above 5%, it indicates that the test is significant. Therefore the model of the study has passed all the diagnostics test as all test proved to be significance as indicated by their probability values.

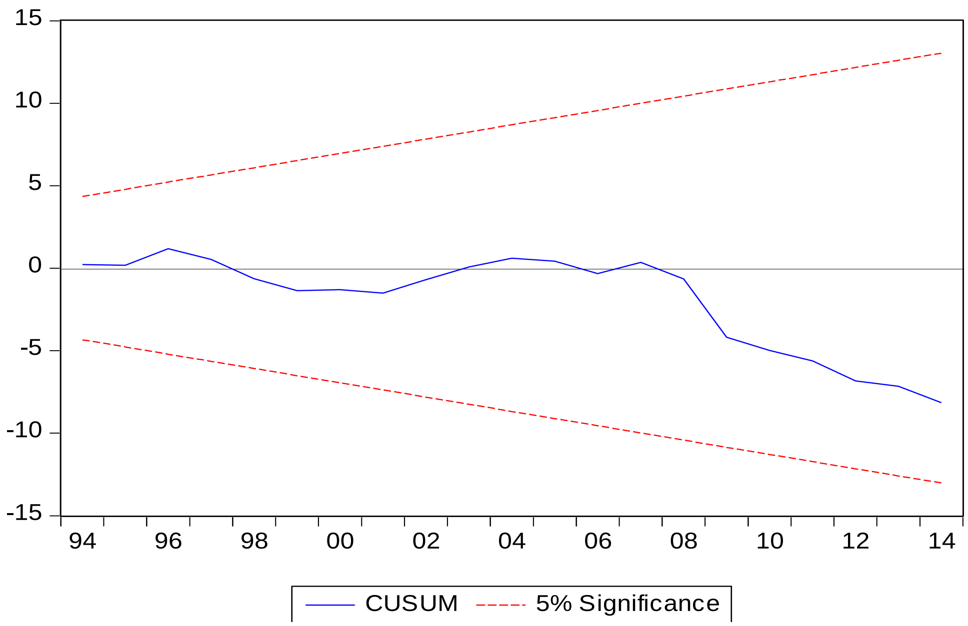
Table 5.8: Stability test

Test	**Null hyphothesis**	**T stats**	**P-value**	**Conclusion**
Ramsey reset test	No misspecification	**0.503444**	**0.6202**	Fail to reject null hypothesis

From the stability test conducted in table 5.8, it can be concluded that there is no misspecification of residuals, the P-value 0.6202 of the test is greater than 0.05% level of significance concluding to the null hypothesis of no misspecification can be accepted.

Cusum test

Figure 5.3 Cusum



Shahbaz and Feridun (2011) found stability for economic growth and electricity consumption for an article based in Pakistan. To test for stability the study performed a CUSUM test, which helps identify if the model and the coefficients, which helps indicate that the model can be used for decision making. The stability of the model is indicated by the constant trend within the 5% level of significance, which is visible in figure 4.3, therefore thee model is concluded to be stable.

5.8 Simulation

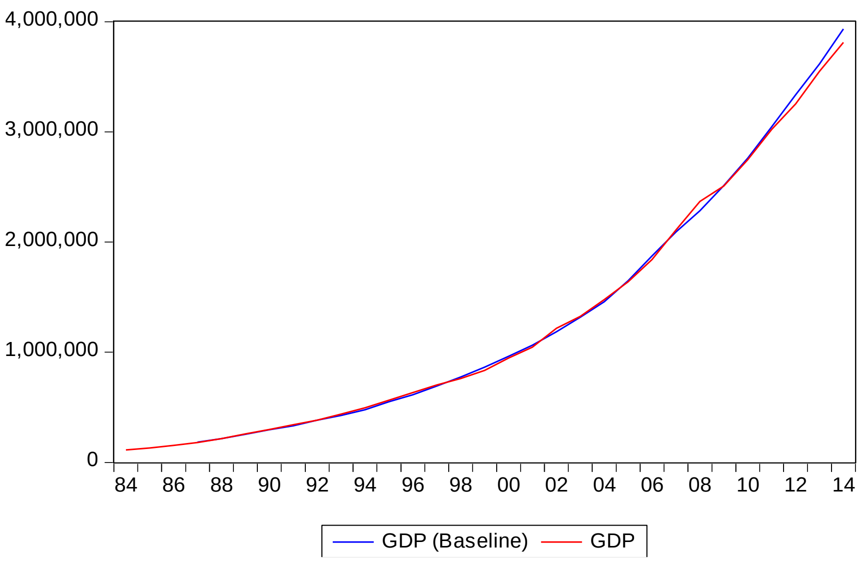
Model specification (equations)

ect_1 = lngdp(-1) - (0.686129 * lnkwhcons(-1) + 0.005212 * lnkwhp(-1) - 0.008589 * income(-1) + 0.041020 * pop(-1) + 4.225888)

lngdp = 0.537603 * d(lnkwhcons) + 0.245871 * d(lnkwhcons(-2)) - 0.035387 * d(lnkwhp) + 0.010829 * d(income) + 0.080367 * d(pop(-2)) - 0.317664 * ect_1 - 0.030952 + lngdp(-1)
gdp = exp(lngdp)

Simulation

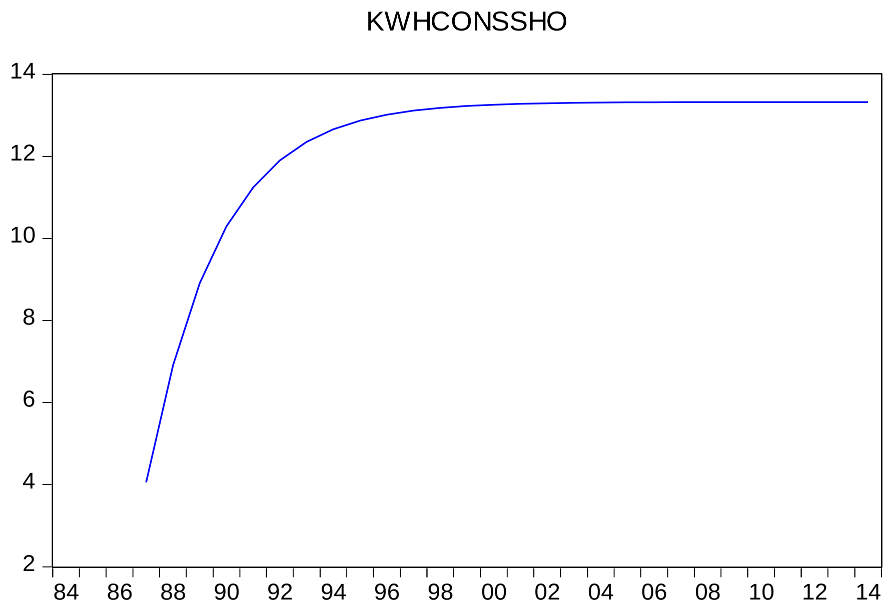
Figure 5.4 Model simulation



The importance of Model simulation is to avoid having conclusions that are biased. Both the error correction model and the error correction model are used to simulate. Figure 4.4 indicates the simulated model which consist of the actual and estimated GDP. The model indicates the rate of significance by the level of tangency between GDP and the estimated GDP which is GDP (baseline).

Shock

Figure 5.5 Model Shock



Interpretation

A shock is applied to Figure 5.5 to identify how the model will respond if one of its variables experiences a shock. This is done by shocking variable LNOPEN, the results to a shock is positive, indicated by an upward trend.

5.9 Conclusion

The relationship between the GDP and Load Shedding was investigated with respect to electricity consumption, other explanatory variables are also presented to further investigate. To test for stationarity, the ADF and PP tests were performed and concluded for no unit root within the series.

The order of integration for variables is indicated to be I (1). The Engle-Granger cointergration along with the Johansen cointegration test were also conducted to test for cointegration concluding that sets follow the same stochastic trend. A long run relationship of variables is indicated in the ECM results. Given the results, it is further concluded that there is a long run relationship between the consumption of electricity and economic growth in South Africa. Shahbaz and. Feridun (2011) found that variables have a long run equilibrium relationship which is similar to the findings in this chapter.

CHAPTER SIX

CONCLUSION AND POLICY RECOMMENDATION

6.1 INTRODUCTION

This section of the chapter takes the analyses and results interpretation of the previous chapter into account, the conclusion of the study is derived from the chapter with respect to the aims and objectives of the study as indicated in chapter one.

6.1.1 Key Findings

The aim of the study was to examine the impact of load shedding towards the South African economic growth. In order to identify this, the study focused more on how electricity in consumed in South Africa. The consumption of electricity is believed to shed insights to how the economic growth reacts to chances in consumption.

To investigate the impact of load shedding on growth, electricity consumption was used as a proxy for load shedding. The long run model also included other key regressor variables such as electricity price, income per capita and population total to identify the order of integration, unit root test where performed which also tasted for stationarity. The Engle Granger cointegration test was performed to identify the trend relationship of growth and electricity consumption. The results of the study indicate that there is a positive relationship between electricity consumption and economic growth in South Africa. The results are supported by the model having to pass all the diagnostics tests for stability and adequacy.

With the results of the ECM, the study finds electricity consumption to be significant to growth, which in return indicates that Load shedding does have a significant impact towards the economic growth of South Africa. This suggests that, black outs that are experienced due to the problem of load shedding do have an impact on the growth of the economy. South Africa being a developing and a middle class country does rely on the consumption of electricity for productivity, and electricity blackouts to affect the productivity level of the country. Load shedding does not only affect productivity but ordinary lifestyles of the citizens of the country depend mostly on energy intensive technologies to get by with their daily activities. This results are in support of those of

Fatai (2014), who found a long run relationship between energy consumption and economic growth, also indicating that energy contributes towards economic growth in the long run

6.2 Policy implications

A bilateral relationship between electricity consumption and economic growth means that electricity consumption results to growth in the economy. This can be supported by the use of electricity in the manufacturing sector, construction sector, small businesses and households. The use of electricity can easily determine the rate of production capacity of one country. In any point whereby electricity is limited or not consumed to its outmost level, the production process can be and will be hindered.

The study gives advice on how to enhance electricity consumption to support growth in the economy taking into account load shedding. As mentioned before in the study, at the imbalances of the past have a lot to do with some economic crises the country faces today, one being load shedding. The infrastructure used to supply electricity during the apartheid years was built to supply electricity only to the minority and not the majority of the country and the infrastructure was only limited to a certain capacity. After 1994 where everyone in the country was given the right to have electricity, the infrastructure could not handle the capacity or the load of supplying the whole country with electricity as it was now old and not fully equipped to keep up with the demand for electricity.

Infrastructure development, investment and maintenance is ideal to ensure that load shedding does not continue to be a problem in the country as efficient supply of electricity is important to many sectors of the country being the primary, secondary and tertiary sector. It is also to be noted that electricity hikes do not prove to be a solution in the middle income country as unemployment is relatively high. With high prices of electricity many will be excluded to benefit from consuming electricity, be economical or personal benefit.

Instead of increasing electricity price to a point whereby it affects the less fortunate negatively, the state may consider investing more in infrastructure development whereby high-tech systems are introduced to ensure that electricity infrastructure is maintained and developed, furthermore it has to build sufficient power plants that will ensure that there is sufficient supply of electricity within the borders of country. If in any case the problem of load shedding continues, the country should also limit its electricity export to neighbouring countries, just to a point whereby the problem of load shedding does no longer exist.

One way to reduce electricity shortcut or load shedding is by introducing other forms of generation electricity like green energy which involves solar energy that converts energy from sunlight into electricity by use of solar power or photovoltaic. Photovoltaic uses solar cells to generate electric power, this will help balance electricity demand and supply.

6.3 Key variables and their impact

Below the significance and the impact of variables are explained with respect to Load shedding.

6.3.1 Gross Domestic product

Many studies do suggest that economic growth granger cause electricity consumption, this suggesting that growth will also result to a decline in electricity consumption. However other empirical evidence suggests that electricity consumption leads to economic growth taking into account that the increase in growth will result to an increase in electricity consumption and a decrease in direct implications of electricity consumption towards productivity as indicated within the study.

6.3.2 Electricity consumption

With respect to electricity consumption its relationship between GDP has been well under study. Many policy makers and economists tried to understand the significance that electricity consumption has on economic growth. Different findings were concluded, stating that there is little relationship between economic growth and electricity consumption, while others like Aqeel (2006) suggests that growth granger causes electricity consumption whereas other studies suggests that electricity consumption granger causes economic growth. That being the case, the study failed to prove any granger causality that exists between growth and electricity consumption, however theoretical evidence indicates the relationship between economic growth and electricity consumption. It is of general knowledge that electricity consumption is the driving force behind productivity which contribute towards economic growth, thus suggesting that there is a possibility of granger causality between electricity as indicated by other studies.

6.3.3 Electricity price

The price of electricity determines the rate of electricity consumption. Load shedding as a problem in the case of South Africa, has caused the price of electricity to increase overtime. In economic theory, if ever there in and increase in demand leads to an increase in prices in order for supply to meet demand. As the demand for electricity tends to increase, supply shortfalls when it comes to meeting the demand and that is when in most cases load shedding takes places, resulting to price hikes in order to combat the problem of load shedding.

6.3.4 Income

Income in the case of electricity and growth, introduces income elasticity of demand. A change in income of an individual will result to a change in the demand for a good (Ramskov and Munksgaard, 2001). The rate of the demand for goods and services will depend solely to whether there is a positive change in income or a negative change in income. A positive change in income will result to an increase in demand for consumption, whereas a negative change in income will result to a negative demand for consumption. Income is also in line with price hikes for electricity, as prices for electricity keep on increasing, the ordinary consumer for electricity must also be able to afford electricity and have the freedom to utilize it according to his or her purchasing power.

Underveloped economies are faced with challenges of income inequality, making it difficult for those who live below the poverty line to function and exercise their economic right. People who cannot afford basic goods and services are deprived to enjoy the benefits that come with those goods and services. There are also people who are unable to enjoy the benefits of electricity consumption as they cannot afford the price that comes with it, however if there is an increase in employment, the purchasing power of the less fortunate will improve which will result to economic growth.

6.3.5 Population

The higher population growth rate, the higher the demand for consumption of any good or services. A country experiencing a high population growth rate like India will always have a problem of demand exceeding supply. The problem of demand exceeding supply is caused by limited resources available for consumption. Economic theory suggests that high population rate results to high employment rate which will automatically result to an increase in consumption, having a positive impact towards growth. However that is not always the case as with limited resources for consumption. There will be a problem of too much money in circulation. In the case of electricity consumption, high demand for electricity is caused by an increase in population, which, like in the case of South Africa resulted to the problem load shedding as supply failed to meet demand.

6.4 Limitations of the study and Areas for further study.

The study concludes that the relationship between electricity consumption and economic growth is significant and that the impact of load shedding is negative towards the growth of the country. Given the problem that the electricity supply is linked to load shedding, this study does not look into other factors that can ensure that there is sufficient supply of electricity that might be from the traditional way of supplying electricity.

Even though there are several studies that are more focused in green energy that is used to produce electricity that is environmental friendly and price efficient on both the producer and the customer, possible future studies can be based on how to collaborate the traditional way of producing electricity with the green energy production and how can the economy benefit from it.

References

Adebola, S. S. 2011. Electricity Consumption and Economic Growth: Trivariate investigation in Botswana with Capital Formation. *International Journal of Energy Economics and Policy*, 1(2), pp. 32-46.

Agénor, P. 2006. A Theory of Infrastructure-led Development. *Working paper* 83. Center of Growth and Business Cycle Research. University of Manchester.

Akitoby, R., Clements, B., Gupta, S. & Inchauste, G. 2006. Public spending, Voracity, and Wagner's law in developing countries. *European Journal of Political Economy*. (22), pp. 908-924.

Anderson, R.L, 1942. Distribution of the Serial Correlation Coefficient. *The Annals of Mathematical Statistic*, 13(1), pp. 1-13.

Anderson, R.M, Eom, K.S, Hahn, S.B and Park, J. 2012.Sources of stock return autocorrelation. *Working paper*. Department of Economics, University of California at Berkely.

Anderson, W.S, and Sedatole, K.L. 2013. Evidence on the cost Hierarch: The Association between Resource Consumption and Production Activities. *Journal of Management Accounting Research*, 25, pp. 119-141.

Asafu-Adjaye, J. 2000. The relationship between energy consumption, Asian developing countries. *Journal of Economics*, (22), pp. 615-625.

Aqeel, A. and Butt, M.S. 2001. The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal*. 8(2), pp. 101-110.

Bekhet, H. A. and Othman, N. S. B. 2011. Assessing the Elasticities of Electricity Consumption for Rural and Urban Areas in Malaysia: A Non-linear Approach. *International Journal of Economics and Finance*, 3(1), pp. 208-217.

Berg, H. 1997. The Relationship between International trade and economic growth in Mexico. *North American Journal of Economics & Finance*, 8(1): pp. 1-21.

Bernetein, M. & Griffin, J., 2006. *Regional Differences in the Price-Elasticity of Demand for Energy*, Santa Monica, California: RAND Corporation.

Best, R., 2003. An Introduction to Error Correction Models. Oxford Spring School for Quantitative. Methods in Social Research. https://www.coursehero.com/file/13398891/Error-Correction-Model-Slidespdf Date Accessed 18 June 2016

Bohi, D. R. & Zimmerman, M. B. 1 984. An Update on Econometric Studies of Energy Demand Behavior. Annual Review of Energy. 9, pp. 105–154.

Brooks, C. 2008. Introductory econometrics for finance 2nd edition. New York: Cambridge University Press. Bulletin, December: pp. 28-29.

Chandra, V.G.R., Sharma, S. & Madhavan, K. 2010. Electricity consumption- growth nexus: the case of Malaysia. *Energy Policy*. 38, pp. 606-612.

Chen, S. T, kuo. K &d Chen. C. C. 2006. Relationship between GDP and electricity consumption in 10 Asian countries. *Energy Policy*. 34(4), pp. 2611-262.

Cheng, B. S. & Lai, T. W. 1997. An investigation of co-intergration and causality between energy consumption and economic activity in Taiwan. *Energy economics*, (19), pp. 435-444.

Chueng.Y, & Lai K. S. 1995. Lag Order and Critical Values of the Augmented Dickey-Fuller Test. *Journal of Business & Economic Statistics*. 16(3): 277-280.

Davidson, R. &MacKinnon, J. G. 2004. Econometric Theory and Methods. New York: Oxford Universityhttp://www.pdfonpoint.com/PDF/Level%20400/pure%20Maths/ECONOMETRICS/ECONOMETRIC%20THEORY%20(2).pdf. Date Accessed 15 October 2015.

Diks. C., & Panchenko. V. 2006. A new statistic and practical guidelines for nonparametric Granger causality testing. *Journal of Economic Dynamics & Control*. 30, pp. 1647–1669.

Eberhard. A. 2011. The Future of South African Coal: Market, Investment and Policy Challenges. *Working paper 100*. Program of Energy and Sustainable Development.

Eberhard. A., Foster. V., Garmendia. C. B., Ouedraogo. F., Camos. D., Shkaratan. M. 2008. Underpowered: The State of the Power Sector in Sub-Saharan Africa. *Working paper 48214* . Africa Infrastructure Country Diagnostic.

Fatai, B. O. 2014. Energy Consumption and economic growth nexus: Panel co-integration and causality tests for Sub-Saharan Africa. *Journal of Energy in Southern Africa*, 25(4), pp. 93-100.

Fedderke, J.W. & Romm, A.T. 2006. Growth impact and determinants of foreign direct investment into South Africa. *South African Journal of Economics*, 73(2). pp. 1-32.

Frischmann, B. M. 2006. *An Economic Theory of Infrastructure and Commons Management*, Chicago*:* Berkeley Electronic Press.

Ghosh, S. 2002. Electricity consumption and economic growth in India. *Energy Policy*, (30), pp. 125-129.

Gualerzi, D. 2011. Long term depression and new markets: economists and the 2008 recession, in: O. Dejuan, E. Febrero & M.C. Marcuzzo (Eds) The First Great Recession of the 21st Century: Competing Explanations (Cheltenham: Edward Elgar).

Halicioglu, F. 2007. Residential electricity demand dynamics in Turkey. *Energy Economics* (29), pp. 199–210.

Hung. M. W and Wang Y.J.R. 2005. Asset Prices under Prospect Theory and Habit formation. *Review of Pacific Basin Financial Markets and Policies*.. 8 (1), pp. 1-29.

Imtriaz, A.K., Mariun, N.B., Amran M. R., M., Saleem, M., Wahab, N.I.A. & Mohibullah. 2006. Evaluation and Forecasting of Long Term Electricity Consumption Demand for Malaysia by Statistical Analysis, First International Power and Energy Conference, (PECon 2006) Proceedings. Art. No.4154502, pp. 257-261.

Jebran, K. 2014. Causal Relationship between Electricity Consumption and GDP in Pakistan. J. Asian Development study, (1). pp. 90-100.

Jumbe, C. B., 2004. Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi. *Energy Economics*, (26), pp. 61-68.

Koen, R. and Holloway, J. 2014. Application of multiple regression analysis to forecasting South Africa's electricity demand. *Journal of Energy in South Africa*, 25(4). pp. 48-58

Koop, G. 2009. Analysis of Economic Data Third Edition. UK: University of Strathclyde .October, pp. 48-96

Lee, C.C. and Chang, C.P. 2008. Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data, Resource and Energy Economics, (30), pp. 50-65.

Michener, R. 2003. Notes on logarithms. January, pp. 1-18.

Moyer. E. J. 2010. Basics on electricity and electrical generation. *Working paper.* University of Chicago.

Nkomo, J.C. 2005. Energy and Economic development: challenges for South Africa. *Journal of Energy in Southern Africa*. 16(3), pp. 10-20.

Odhiambo, N. M. 2009. Electricity consumption and economic growth in South Africa: A trivariate causality test. *Energy Economics,* 39, pp. 635–640.

Odhiambo, N. M. 2010. Energy Consumption and Economic growth nexus in Tanzania. An ADRL bounds resting approach. Energy policy, (37). pp. 617- 622.

Phillips, P.C.B. & Perron,P. 1988, Testing for a unit root in time series regression, Biometrika, (75), pp. 335-346.

Ramskov, J. & Munksgaard, J. 2001. Elasticities – a Theoretical Introduction. February, pp. 1-16.

Renne L. & Jennifer H. 2014. Application of Multiplier regression analysis to forecasting South Africa's electricity demand. *Journal of Energy in Southern Africa*, 25(4), pp. 48-58.

Rufael- Wolde, Y. 2006. Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy Policy.* (34), pp. 1106–1114

Schutte, A.J., Maré, P. & Kleingeld, M. 2013. Improved utilisation and energy performance of a mine cooling system through control of auxiliary systems. *Proceedings of the 10th International Conference on the Industrial and Commercial Use of Energy*. CPUT, Cape Town, South Africa.

Shahbaz, M. & Feridun, M. 2011. Electricty Consumption and economic growth, emperical evidence from Pakistan. Springer. (46), pp. 1583-1589

Shen-Tung Chen, H.-I. K. C.-C. C. 2007. The relationship between GDP and electricity consumption in 10 Asian countries. *Energy policy,* (23), pp. 2611-2621.

Soytas, U. & Sari. R. 2003. Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. *Energy Economics*. (25), pp. 33–37.

Stern D.I. 2010. The role of energy in Economic growth. CCEP working paper 3.10. crouford school, The Australian National University.

http://www.eskom.co.za/AboutElectricity/ElectricityTechnologies/Pages/Coal_Power.aspx Date Access: 12 June 2015

Strengers, Y. 2012. 'Peak electricity demand and social practice theories: Reframing the role of change agents in the energy sector', *Energy Policy*, (44), pp. 226-234.

Winkler, H. 2005. Renewable energy policy in South Africa: policy options for renewable electricity. *Energy Policy*. 33 (2005). Pp, 27–38

Yoo, S.H. 2005. Electricity consumption and economic growth: evidence from Korea. *Energy Policy*. (33), pp. 1627-1632.

Yuan, J., Zhao, C., Yu, S. & Hu, Z. 2007. Electricity consumption and economic growth in China: Cointegration and co-feature analysis. *Energy economic*. (6), pp. 1179-1191.

Appendix

Data for thesis

year	income	dgp	kwhcons	kwhp	pop
1984	11.94	114104	8336	3702	32.21
1985	12.59	131676	9999	4611	32.98
1986	11.91	154289	12063	5367	33.73
1987	11.1	180339	14522	6489	34.46
1988	10.76	216381	16768	7722	35.19
1989	11.27	259726	19740	8797	35.96
1990	11.64	298971	23650	10302	36.79
1991	11.11	342245	25933	11393	37.69
1992	10.68	383723	29855	12171	38.65
1993	10.4	438884	33140	13586	39.62
1994	9.5	496233	36438	15589	40.56
1995	9.56	563870	41908	16985	41.43
1996	8.35	634611	47159	18158	42.2
1997	7.55	703117	52883	19442	42.91
1998	6.88	761658	59625	19976	43.56
1999	6.51	834753	67055	20697	44.2
2000	6.59	946324	75393	22249	44.85
2001	6.82	1046144	82934	22475	45.51
2002	6.72	1217265	94771	26092	45.546
2003	6.88	1325766	107434	25175	46.127
2004	6.55	1476623	132380	27303	46.728
2005	6.25	1639254	150408	28417	47.349
2006	5.98	1839400	166627	30849	47.992
2007	5.79	2109502	187678	33278	48.657
2008	5.93	2369063	203399	37779	49.344
2009	6.05	2507677	225161	53473	50.056
2010	6.25	2748008	249599	67940	50.792
2011	6.47	3023659	274270	86547	51.553
2012	6.29	3253970	297808	105731	52.342
2013	6.03	3549153	315974	117400	53.157
2014	5.87	3812607	337218	127154	54.002

ECM

Dependent Variable: DLNGDP
Method: Least Squares
Date: 10/24/16 Time: 11:27
Sample (adjusted): 1987 2014
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNKWHCON	0.537603	0.159002	3.381100	0.0028
DLNKWHCON(-2)	0.245871	0.153059	1.606381	0.1231
DLNKWHP	-0.035387	0.054858	-0.645059	0.5259
DPOP(-2)	0.080367	0.028862	2.784533	0.0111
DINCOME	0.010829	0.011261	0.961659	0.3472
ECT(-1)	-0.317664	0.145262	-2.186842	0.0402
C	-0.030952	0.030759	-1.006277	0.3257

R-squared	0.619548	Mean dependent var	0.114544
Adjusted R-squared	0.510847	S.D. dependent var	0.031188
S.E. of regression	0.021813	Akaike info criterion	-4.600308
Sum squared resid	0.009992	Schwarz criterion	-4.267257
Log likelihood	71.40432	Hannan-Quinn criter.	-4.498491
F-statistic	5.699580	Durbin-Watson stat	2.212279
Prob(F-statistic)	0.001202		

LONG RUN MODEL

Dependent Variable: LNGDP
Method: Least Squares
Date: 10/24/16 Time: 11:32
Sample: 1984 2014
Included observations: 31

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNKWHCONS	0.686129	0.070226	9.770290	0.0000
LNKWHP	0.005212	0.061184	0.085193	0.9328
INCOME	-0.008589	0.014239	-0.603208	0.5516
POP	0.041020	0.020710	1.980669	0.0583
C	4.225888	0.309211	13.66667	0.0000

R-squared	0.998948	Mean dependent var	13.59420
Adjusted R-squared	0.998786	S.D. dependent var	1.055498
S.E. of regression	0.036771	Akaike info criterion	-3.621527
Sum squared resid	0.035155	Schwarz criterion	-3.390239
Log likelihood	61.13367	Hannan-Quinn criter.	-3.546133
F-statistic	6173.182	Durbin-Watson stat	0.608391
Prob(F-statistic)	0.000000		

Pairwise Granger Causality Tests
Date: 10/31/16 Time: 23:32
Sample: 1984 2014
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
LNKWHCONS does not Granger Cause LNGDP	29	4.74300	0.0184
LNGDP does not Granger Cause LNKWHCONS		0.13657	0.8730
LNKWHP does not Granger Cause LNGDP	29	0.54256	0.5882
LNGDP does not Granger Cause LNKWHP		1.00077	0.3824
INCOME does not Granger Cause LNGDP	29	0.43293	0.6536
LNGDP does not Granger Cause INCOME		2.78709	0.0816
POP does not Granger Cause LNGDP	29	0.02035	0.9799
LNGDP does not Granger Cause POP		2.08090	0.1468
LNKWHP does not Granger Cause LNKWHCONS	29	1.84906	0.1791
LNKWHCONS does not Granger Cause LNKWHP		2.44972	0.1076
INCOME does not Granger Cause LNKWHCONS	29	1.78184	0.1899
LNKWHCONS does not Granger Cause INCOME		0.47159	0.6297
POP does not Granger Cause LNKWHCONS	29	1.84918	0.1791
LNKWHCONS does not Granger Cause POP		1.78602	0.1892
INCOME does not Granger Cause LNKWHP	29	0.72767	0.4934
LNKWHP does not Granger Cause INCOME		1.82676	0.1826
POP does not Granger Cause LNKWHP	29	5.76043	0.0091
LNKWHP does not Granger Cause POP		4.41380	0.0233
POP does not Granger Cause INCOME	29	0.79147	0.4647
INCOME does not Granger Cause POP		5.05415	0.0147

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.589830	Prob. F(2,19)	0.5643
Obs*R-squared	1.636820	Prob. Chi-Square(2)	0.4411

Heteroskedasticity Test: White

F-statistic	0.380920	Prob. F(6,21)	0.8829
Obs*R-squared	2.748258	Prob. Chi-Square(6)	0.8397

	Value	df	Probability
t-statistic	0.503444	20	0.6202
F-statistic	0.253455	(1, 20)	0.6202
Likelihood ratio	0.352608	1	0.5526

MODEL SCHOCK

Model: MODELSHOCK

Date: 10/24/16   Time: 11:35

Sample (adjusted): 1987 2014

Solve Options:

Dynamic-Deterministic Simulation

Solver: Broyden

Max iterations = 5000, Convergence = 1e-08

Parsing Analytic Jacobian:

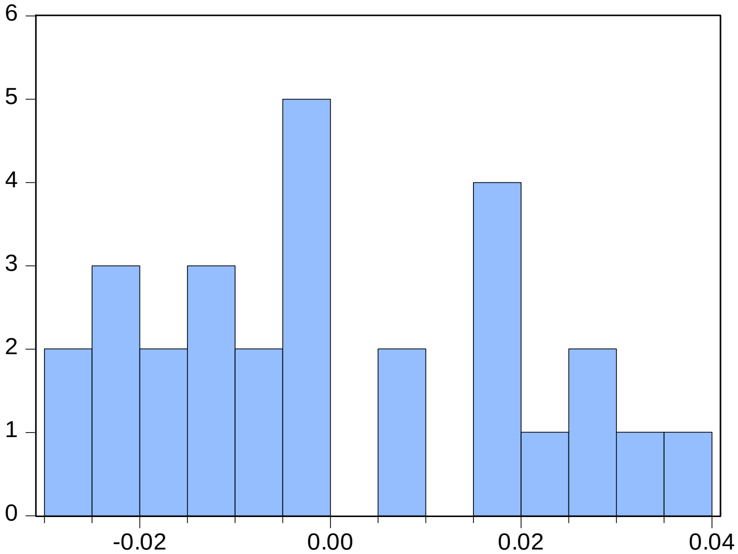
0 derivatives kept, 0 derivatives discarded

Scenario: Baseline

Solve begin 11:35:16

Solve complete 11:35:16

Histrogram



Series: Residuals	
Sample 1987 2014	
Observations 28	
Mean	9.54e-18
Median	-0.003903
Maximum	0.037078
Minimum	-0.027264
Std. Dev.	0.019237
Skewness	0.346884
Kurtosis	1.879490
Jarque-Bera	2.026332
Probability	0.363068