Examining the relationship between electricity consumption and economic growth in Uganda

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D e c l a r a t i o n

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A b s t r a c t

This study examined the causal relationship between electricity consumption and economic growth in Uganda during the period 1960–2014. Inasmuch as there have been similar studies done on the African continent on this relationship, none has been done in Uganda. The objectives of the study were threefold: 1) to estimate the short--run and long--run relationship between electricity consumption and economic growth in Uganda; 2) to examine the direction of the causal relationship; and 3) to propose policies to guide future decision making of government. To achieve these objectives, the study adopted the Auto Regressive Distributed Lag bounds approach in analysing the level of relationship. In addition, the study used the pairwise Granger Causality testing procedures to determine the direction of causation between the study variables. Results from the study indicated that there is a valid long-run level relationship between electricity consumption and economic growth. In addition, the pairwise Granger causality tests indicated that the relationship is unidirectional, running from electricity consumption to economic growth. Overall, the study found that energy consumption spurs economic growth in Uganda. The government should fast-track and consolidate interventions in electricity generation with the view of sustaining the long-run electricity demand and consumption in Uganda. In the short run, investments to improve energy efficiency and reduce losses should make more electricity available for consumption.

Key words: Electricity Consumption, Economic growth, Uganda

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List of Acronyms and Abbreviations

ADF	Augmented Dickey-Fuller
ADFL	Augmented Dickey-Fuller Unit Root Test
AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
CUSUM	Cumulative Sum
ECM	Error Correction Model
ECOWAS	Economic Community for West African States
ERA	Electricity Regulatory Authority
ESI	Electricity Supply Industry
FPE	Final Prediction Error
GDP	Gross Domestic Product
GNP	Gross National Product
GoU	Government of Uganda
HQ	Hannan-Quin
IMF	International Monetary Fund
LR	Linear Regression
MEMD	Ministry of Energy and Mineral Development
NP	Nakivubo Pronouncement
NPA	National Planning Authority
NRM	National Resistance Movement
P-P	Phillips-Perron
SC	Schwartz Information Criterion
SSA	Sub-Saharan Africa
UBOS	Uganda Bureau of Statistics
UDC	Uganda Development Corporation
UEB	Uganda Electricity Board
UEDCL	Uganda Electricity Distribution Company Limited
UETCL	Uganda Electricity Transmission Company Limited

UNHS	Uganda National Household Surveys
VAR	Vector Auto Regression
VECM	Vector Error Correction Model

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

Electricity is an important input in production processes. Without heat, light and power it is impossible to build or run industries and cities that provide goods, jobs and homes, or to enjoy the amenities that make life easy and enjoyable. Electricity is the 'oxygen' of the economy and the life-blood of growth, mainly in the mass industrialisation phase of economic development.

The energy industry contributes to economic development in two ways. First, energy is an important sector in its own right, which creates jobs and value, by extracting, transforming and distributing energy goods and services throughout the economy. Secondly, energy underpins the rest of the economy. Energy is an input for nearly all goods and services. In many countries, the flow of energy is usually taken for granted. However, price shocks and supply interruptions affect the whole economic set-up. For countries such as Uganda, which face chronic power (electricity) shortages, continuous disruptions take a heavy toll on economic activity. Electricity, for example, is critical in the delivery of basic social services like education and health. Electricity also helps to power machines that support income-generating activities (for instance pumping water for agriculture, food processing, and light manufacturing). Lack of modern energy services in rural areas limits the willingness of professionals (teachers, doctors, nurses,) to live and work in these areas, further limiting services and opportunities to local populations. There is strong evidence linking availability of energy and social economic development.

This study examines the empirical relationship between electricity consumption and economic growth in Uganda. Importantly, the study seeks to establish the direction of causality between electricity consumption and economic growth. A key question here is: Does electricity consumption lead to economic growth, or is it economic growth that leads to increased electricity consumption?

1.2 CONTEXT OF RESEARCH

After her independence in 1962, Uganda suffered a disruptive civil war that economically drained the economy from 1971 to 1986. During this period, the economy shrunk to the lowest growth of 11 percent in 1978. Electricity consumption was equally hit, with consumption reducing from 451 million KWh in 1971 to 235 million KWh in 1979. The infrastructure was left unattended, and industries closed following the expulsion of Asians in the late 1970s and as a result consumption reduced.

Whereas there are no empirical studies linking this period's performance to the reduction in electricity consumption, studies conducted in other countries have supported the assertion that

households, government and industries all need electricity to ensure sustainability of their business operations (Kouakou, 2011). Electricity consumption increases with the rate of economic development and improves the standards of living of its citizens (Bildirici, 2013). Provision of reliable and affordable electricity affects growth of the economy through consumption and production stimulation, hence improved capital and labour productivity. For instance, an increase in the price of electricity increases the cost of doing business, which in turn affects the growth of the economy.

The GoU had to license thermal generators between 2005–2006 and 20011–2012 when, as a result of slow investment in the generation sector, demand exceeded supply and expensive thermal generators had to be called in to rescue the situation. Whereas the economy grew during these periods, the long-term effect of this action has never been investigated.

Consumption of electricity and the GDP have increased over the years from 202 million kWh in 1960 to 2,297 million kWh in 2014, and from US$423 million in 1960 to US$26,312 million in 2014 respectively (World Bank, 2014). However, the extent to which each variable impacts on the others is not clear. It is hypothesised that electricity consumption causes the growth of the economy and this study will investigate the existence of this assertion in Uganda.

1.3 GENESIS OF THE STUDY

In 1952, Uganda commissioned the 180 MW Nalubale Hydro Power Plant located on the shores of River Nile. According to Obwona, Shinyekwa, Kiiza and Hisali (2014), the dam was constructed to promote British manufacturing in the then colony – Uganda. Almost fifty years later, in early 2000, an additional 200 MW installed capacity was commissioned at Kiira on the same River Nile to meet the electricity demand in the country.

In 1999, through an Act of Parliament, the government liberalised the economy by unbundling the electricity sector to create an energy regulator: the Electricity Regulatory Authority (ERA) and independent power producers (generators) and distributors. The unbundling aimed at reducing operational inefficiencies that had characterised the former body while increasing accessibility and attracting investments in the sector (Mawejje, Munyambonera & Bategeka, 2013).

In August 2012, Bujagali Power Plant (250 MW) was commissioned bringing the total generation capacity for the country to 821 MW (ERA, 2013). This capacity was low compared to the biggest economy in the region, Kenya, at 1,337 MW (KenGen, 2014) and the second largest, Tanzania, at 1,606MW (EWURA, 2014). To increase generation and attract investment in the sector, a number of policies and regulations have been put in place.

According to the 2014-2015 annual report (ERA, 2015), the government with support from development partners led by Kreditanstalt für Wiederaufbau (KfW) of Germany under the Global

Energy Transfer Feed in Tariff (GETFiT) project, formed an initiative aimed at accelerating the development of renewable energy resources to bridge the demand–supply gap. By the end of the financial year 2014/15, seven projects had signed power purchase agreements with the government.

According to ERA (2014) there were 34 operational licensed companies in the distribution, generation and transmission segments of the Electricity Supply Industry (ESI). Whilst there has been an increase in the number of companies licensed, accessibility has only increased by 3.4 percent from 14.6 percent in 2010 (World Bank, 2010) to 18 percent in 2014 (ERA, 2014). Through the Vision 2040, the government has highlighted the need to increase electricity generation and accessibility among the main drivers for the country to attain middle-income status by 2040.

Inasmuch as economic growth in countries like Hong Kong (Chen, Kuo & Chen, 2007), Malaysia (Tang, 2008), Singapore (Yoo, 2006) and Turkey (Erdal, Erdal, & Esengün,(2008), has partly been attributed to increased electricity consumption, other developing countries such as Taiwan (Pao, 2009) and Saudi Arabia (Mehrara, 2007) have had different experiences. In the latter countries, economic growth has been attributed to factors other than electricity consumption, while countries like Qatar (Payne, 2010) showed a neutral effect between the two variables.

Uganda's effort to increase economic growth should be supported by an adequate and reliable electricity supply. The fundamental question that this study addresses is whether there is a causal relationship between electricity consumption and economic growth in Uganda.

1.4 PROBLEM STATEMENT

From the 1970s, studies have been done on the causal relationship between electricity consumption and economic growth in both developed and developing countries. However, a number of these studies concentrated on the Asian and American economies, giving little attention to the African continent and more specifically Sub-Saharan Africa. In fact, empirical studies on countries such as Uganda are non-existent.

Moreover, where such studies have been conducted, the findings on the direction of the causality relationship have been inconsistent and largely inconclusive. What empirical studies show, however, is that the relationships between different countries differ from time to time, and that the relationship has shown sensitivity to the choice of variables on this nexus.

as Although the majority of these studies have found a direct causal relationship between electricity consumption and economic growth, others have observed a neutrality nexus. Moreover, even where the relationship has existed, some countries have shown a bi-directional or uni-directional relationship, further complicating the situation.

Past empirical studies have used cointegration analysis based on a number of methodologies including Engle and Granger (1987), Johansen (1988) and Johansen and Juselius (1990) in determining the causal relationship. Studies have also shown that these cointegration methods are not appropriate especially when the sample size is too small (Narayan & Smyth, 2005). Other studies have used cross-sectional data analysis, which in itself is not bad except that by grouping countries that are at different stages of development, it fails to address country-specific details. This study uses the Autoregressive distributed lag (ARDL) bounds testing method to determine the existence and direction of the causal relationship between electricity consumption and economic growth. This study also investigates the kind of relationship that exists: unidirectional, bidirectional or no causality at all.

1.5 RESEARCH OBJECTIVES

The overall objective of this study is to investigate the existence of a level relationship between electricity consumption and economic growth in Uganda. The specific objectives of the study are to:

i) To estimate the short run and long run relationship between electricity consumption and economic growth in Uganda;
ii) Examine the direction of the causal relationship.

The research questions to be answered at the end of this study arising from the above objectives are:

i) What is the nature of the short run and long run relationship between electricity consumption and economic growth in Uganda?
ii) What is the direction of causality between electricity consumption and economic growth in Uganda?

1.6 RESEARCH METHODOLOGY

The research was conducted using quantitative research techniques and procedures. The study involved a review of theoretical studies, empirical literature and annual statistical data from 1960 to 2014. It adopted the use of ARDL bounds testing procedures and Granger Causality tests to make inferences about the nature of the relationships between electricity consumption and economic growth in Uganda.

1.7 DATA COLLECTION

The study used secondary data for the empirical analysis to address the research objectives. The data used is on an annual basis from 1960 to 2014. Electricity consumption is expressed in terms of kilowatt hours (kWh), while economic growth will expressed in millions of United States dollars.

Both sets of data are publicly available from the World Bank website, the Electricity Regulatory Authority (ERA) database and the library.

1.8 DATA ASSESSMENT AND ANALYSIS

The data was analysed using the STATA 12 programme and analysed to establish the extent of relationship that exists between the variables. Data were tested for stationarity to determine the order of integration of the study variables and the strength of the linear relationship that exists between the variables. Electricity consumption is the independent variable, while economic growth will be the dependent variable. Results of the findings of the study will be presented in tables. A detailed description of the methodology will be discussed in Chapter 4.

1.9 SCOPE OF THE STUDY

Electricity consumption is part of the bigger industry activities included together with mining and quarrying, manufacturing, water and construction. Whereas economic growth is very much influenced by other sectors which also use electricity, the study will focus on understanding the relationship between economic growth and electricity consumed by all the sectors in the economy. To ensure a representative sample for reliable results, an annual consumption trend will be observed on all the electricity consumed in Uganda from 1960 to 2014.

1.10 OUTLINE OF THE STUDY

This study is organised in six chapters. Chapter 1 provides the introduction to the research. Chapter 2 gives an overview of Uganda's economy, the historical performance of electricity consumption and economic growth trends. Chapter 3 provides the theoretical framework, concept definition, and the empirical determinants of economic growth and impact of electricity consumption on economic growth. Chapter 4 discusses the methodology used, data type and source as well as the sampling method and selection. Chapter 5 presents and discusses the findings. Finally Chapter 6 summarises the major findings and conclusions of the research report, discusses the limitations of the study, and suggests further areas of research to policy makers.

CHAPTER 2
UGANDA'S ECONOMIC OVERVIEW AND THE ELECTRICITY SUPPLY INDUSTRY

2.1 INTRODUCTION

This chapter provides an overview of Uganda's economy, the structure of the electricity supply industry and consumption trends over the years. It is structured in five subsections: an introduction, an overview of Uganda's economy, the current electricity supply industry structure and consumption trends, economic growth trends, and lastly the conclusion.

2.2 OVERVIEW OF UGANDA AND ITS ECONOMY

Uganda is a landlocked country located in the eastern part of Africa. It boarders Kenya in the east, the Democratic Republic of Congo in the west, Rwanda in the south west, South Sudan in the north, and Tanzania in the south. According to the National Planning Authority (2013), the country measures 241 038 square kilometres (equivalent to 93 065 square miles) with the water bodies and wetlands covering 15 percent. The preliminary 2014 National Population and Housing Census (NPHS) results indicate a population of 34 856 813 of which 60 percent are below the age of 18 years (NPHS, 2014).

The country generates its income through annual exports from agricultural products such as coffee, tea, fish and other products. This sector according to the Uganda Bureau of Statistics (UBOS, 2014) provided employment to 72 percent of the population. Development in Uganda is skewed mainly to the urban areas where 28 percent of the population live and work compared to 72 percent of their rural counterparts. This tilt is attributed among other things to social infrastructure developments such as electricity, roads, and access to markets in urban areas than as opposed to rural areas.

2.3 UGANDA'S ECONOMIC GROWTH JOURNEY

Uganda's economic growth journey has been characterised by successes and failures since independence in October 1962. Since independence, the country has had a number of economic reforms with its different political regimes (Bigsten & Kayizzi-Mugerwa, 1999). The post-independence period of 1962–1989 focused on inward-looking reforms focusing on import substitution, central planning and licensing. According to Bigsten and Kayizzi-Mugerwa (1999), this was abandoned by Amin's regime of 1970–1979. The country remained in a state of political and economic turmoil until 1986 when the current regime took over power for the second time under president Dr. Apollo Milton Obote. The current regime led by H.E. Yoweri Kaguta Museveni has so

far seen a number of economic and political reforms aimed at reforming the economy. These reforms have resulted in an average growth of 6.4 percent from 1986 to 2014 (World Bank, 2014).

Uganda's economic growth has been structured in three phases: the post-colonial regime under Dr. Apollo Milton Obote (1962–1970), Field Marshal Idi Amin Dada's regime (1970–1979), a stagnation period (1980–1985), and the National Resistance Movement (NRM) regime of 1986 to date.

2.3.1 Post-independence Obote I regime (1962–1970)

Prior to independence, the country's funding was supplemented by sources from the colonial power – the United Kingdom (Obwona, 2001). After independence, the new administrators were faced with challenges both political and economic. These included looking for alternative sources of funding the country programmes amidst fears of being seen to be incompetent. Bigsten and kayizzi-Mugerwa (1999) point out that the new policy makers needed to demonstrate their capability by addressing the challenges left by the colonial masters. Secondly, they were worried about political competitors and discouraged all forms of independent views from the public. Thirdly, they thought that by taking control of all the major sectors of the economy, they would suffocate the other political players.

Industrialisation of the economy was viewed as the best alternative compared to agriculture in answering their quest, since it had backward and forward linkages to spur economic growth. According to Obwona (2001), industrialisation would create employment for the youth and a market for their products. This strategy was further boosted by the existence of the Uganda Development Corporation (UDC) that had been formed by the British in 1952, coinciding with the commissioning of the Owen Falls dam. They forgot that most of the population were peasant farmers practising on a small scale to sustain industrial production input.

At the time, the state and a few Asian and British investors owned industries and these sustained the economy during the post-independence era (Obwona, 2001). In 1964 the Foreign Investment Protection Act was promulgated. This was meant to stop the government from nationalising foreign investments (Obwona, 2001). The UDC had been started to provide investment capital and later sell the rights to the locals, keeping a 51 percent control of the business it had started. However, this was short-lived following the 1968 Common Man's Charter (CMC) and the Nakivubo pronouncement (NP) of 1970 which spelt out strategies to implement the charter. The NP had increased the government control from 51 percent to 60 percent in all the major manufacturing firms.

The government issued its first post-colonial national development plan aimed at raising the standards of living for its peasant citizens. This introduced policy initiatives towards agricultural sector in the areas of research, subsidies and fertilisers.

During this period, electricity consumption and economic growth were on a positive growth trend with exception of economic growth in 1961 as seen in Table 2.1. This could be attributed to the uncertainty that surrounded the struggle for independence.

Table 2.1: Economic growth, population and electricity consumption 1960–1970

	1960	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**	**1970**
GDP growth (%)	3.2	-1.1	4.1	11.7	7.5	0.9	6.3	5.1	32.	11.7	0.7
Electricity (millions of kWh)	202	209	228	271	293	332	376	397	434	445	415
Population (millions)	6.6	6.8	7.1	7.4	7.7	8.0	8.4	8.7	9.1	9.4	9.8

Source: Background to the budget 1956-1965; Statistical Abstract, 1965; UEB report and accounts 1999; and World Bank: World Development Indicators Database

As the business environment became tense, the political environment was also ripe for a change, and the civilian government was replaced be a military government in 1970 led by Field Marshal Idi Amin Dada.

2.3.2 The Amin regime 1970–1979

The economic temperature that had started warming was heated up with Amin's regime in power. Whereas Obote's regime was blamed for concentrating on politics at the expense of the economy and the populace (Uganda, 1972), the military regime led by Idi Amin was to have a fundamental effect on both the population and the economy at large. Amin immediately embarked on the implementation of the NP but with aggression. His rule was characterised by brutality marked with the economic war that culminated in the expulsion of British and Asians in 1972.

Bigsten and Kayizzi-Mugerwa (1999) argue that whereas the resentment against the Asians and the Britons had been there during the 1960s, no one had expected their expulsion. Following the expulsion, Amin's government re-distributed some companies and industries to Ugandans to manage while others were put under the administration of the UDC and other government ministries (Obwona, 2001). Jamal (1976) argues that whereas the inequality between the African majority and the Asians had been there, the redistribution of industries did not improve the welfare of local Ugandans. Instead, this action put Uganda's investment climate to the test, creating hostility, political insecurity and instability and climaxing with the collapse of the East African community.

The economy began to crumble (see Table 2.2) on account of three factors: first, the new managers of the acquired industries were unskilled and uneducated and lacked business acumen. Secondly, the economy was seen to be hostile to investors and a state of lawlessness, and thirdly, the manner of acquisition of businesses did not offer any systematic way of ownership hence there was misuse of assets. The new managers lacked the will and contacts to replenish the stock that had been acquired. Sooner rather than later, the country experienced shortage of almost everything and this led to a spike in consumer prices (Obwona, 2001).

Table 2.2: Selected indicators of economic growth 1970–1980

	1971	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
GDP growth (%)	-0.2	1	-1	-2	-2	1	-1.6	-5.5	-11	-3.4
Electricity (millions of kWh)	451	442	399	398	382	346	332	329	235	240
Population (millions)	10.1	10.3	10.6	10.9	11.2	11.5	11.9	12.3	12.7	13.1

Source: Bank ground to the budget various years, Statistical Abstract, various years, Uganda Electricity Board (UEB) report and accounts, 1999, World Bank: World Development Indicators Database

The allocation of industries to the locals expanded the public sector and Bigsten and Kayizzi-Mugerwa (1999) argue that the number of parastatals had increased from 10 in 1972 to 23 by the mid-1970s. The expansion temporarily supported the economy in 1972 and 1973 (see Table 2.2) through provision of tax revenues and employment to unskilled managers. They argues that these parastatals were soon used for state patronage before their collapse (see Table 2.2 in 1977–1980).

In an attempt to correct the shocks in the economy, the Amin's government adopted to tighten controls, especially on consumer goods. The production of sugar in the country had declined, forcing prices to skyrocket. Introduction of licenses to deal in sugar and other punitive measures on smugglers could not help the situation. In addition, these regulations had an impact on the economy.

Amin's rule not only disorganised the economy but also destroyed infrastructure and the manufacturing industries in the country. Electricity consumption began to decline following the collapse of industries (see Table 2.2). Connection rates became low while collection rates, illegal connections and energy losses increased because of major lawlessness. Despite the economic decline, the population continued to grow over the years from 10.1 million in 1971 to 13.1 million in 1980, an increase of 30 percent.

In the end, the popularity that Amin had hoped to retain from the populace could not be sustained and his regime was overthrown with the help of the combined forces from the diaspora and the Tanzanian government.

2.3.3 Post Amin era 1981–1986 (Obote II)

During this period, there was a leadership vacuum that increased insecurity and weakened all attempts to jump-start the economy. Between 1979 and1980, three presidents ruled the country until the Uganda People's Congress (UPC) party led by Dr. Apollo Milton Obote assumed power in 1981.

Obote's government immediately sought the support of the International Monetary Fund (IMF) and the World Bank to stabilise the economy. A number of policies were outlined to improve production efficiency and prudent use of resources, and create incentives to both domestic and foreign investors (Bigsten & Kayizzi-Mugerwa, 1999). The policies introduced aimed at floating the Ugandan shilling, increasing producer prices for export crops, removal of price controls, rationalisation of tax structures, and reduction of government expenditure while increasing accountability.

These reforms had started to yield fruit until a gorilla was block out in 1984 (see Table 2.3). The war abruptly meant an increase on the military expenditure and its promise of keeping within the limits agreed with the donors was abandoned. Bigsten and Kayizzi-Mugerwa (1999) note that in 1984 alone, the expenditure in wages shoot up four times while the bank credit to government increased by 70 percent and the money supply by 127 percent. Inevitably, the IMF had to withdraw its standby programs.

Table 2.3: Selected indicators of economic growth 1981–1986–1986

	1981	**1982**	**1983**	**1984**	**1985**	**1986**
GDP growth (%)	4.0	5.7	7.4	-8.5	2.0	0.3
Electricity Consumption (Millions of kWh)	288	286	251	282	244	299
Population (Millions)	13.4	13.8	14.1	14.5	14.8	15.2

Source: Back ground to the Budget, various years, Statistical abstract various years, Uganda Electricity Board (UEB) report and accounts, 1999, World Bank: World Development Indicators Database

With the withdrawal of IMF support to the government and the military expenditure in early 1986, the economy was left to collapse. In 1984, as the country embarked on the purchase of military

hardware, consumer goods became scarce forcing people to smuggle produce out of the country to survive hence avoiding taxes. Looting became the order of day accompanied by insecurity resulting in shortage of fuel and consumer goods as noted by Bigsten & Kayizzi-Mugerwa, 1999.

Inevitably, Obote's second coming was cut short after five years in power. The NRM government led by H.E. General Y.K. Museveni assumed power from 1986 to date.

2.3.4 The NRM regime 1986 to date

When the NRM government took over power on 27 January 1986, they promised to bring a fundamental change not only to the political scene but also to the economy. In May 1987, the government introduced its first Economic Recovery Program (ERP) supported by the World Bank and IMF. The programme aimed at stabilising the economy, stimulating the growth of the economy and maintaining a sustainable balance of payment position for the country. To achieve this, the government needed to implement other public sector, market, price and exchange rate reforms (Bigten and Kayizzi-Mugerwa, 1999).

Three years later, reforms paid off with the support of donor funding inflow, internal security and expansion of industries and agricultural activities. However, towards the end of the 1980s, export incomes began to fall due to the collapse of global coffee prices and this created pressure on the government which had a small export base. The insurgency of the Lakwena rebel group in the northern part of the country did not make the situation any easier, and forced the government to increase expenditure on defence. By mid-1989, the economy had begun to stabilise with a positive growth in the economy (see Table 2.4).

Table 2.4: Selected indicators of economic growth 1987–2014

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP Growth (%)	3.96	8.27	6.36	6.47	5.55	3.42	8.33	6.40	11.52	9.07	5.10	4.91	8.05
Consumption (Million KwH)	338	263	282	351	525	486	476	488	522	677	701	706	701
Popn (Million)	15.74	16.32	16.92	17.53	18.16	18.79	19.43	20.08	20.74	21.41	22.08	22.78	23.51

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
GDP Growth (%)	3.14	5.18	8.73	6.47	6.81	6.33	10.78	8.41	8.71	7.25	5.17	9.67	4.41	3.27	4.51
Consumption (Million KwH)	843	913	877	1,038	1,033	1,075	990	1,138	1,280	1,405	1,636	1,745	1,954	2,110	2,297
Popn (Million)	24.28	25.09	25.94	26.84	27.77	28.72	29.71	30.73	31.78	32.86	33.99	35.15	36.35	37.58	38.84

Source: World Bank: World Development Indicators Database, Uganda Electricity Board (UEB) report and accounts, 1999,

The government continued to introduce reforms in the sector to strengthen the Ugandan shilling as well as the other sectors of the economy. In 1990, liberalisation of the foreign exchange market was introduced, allowing foreign exchange bureaus to operate alongside the commercial banks.

According to Kasekende and Ssemogerere (1994) this move was intended to legalise the black market while the Bank of Uganda continued to conduct supervision and weekly auctions of foreign currency. Eventually, the gap between the bureau exchange rate and the official rate reduced but never disappeared due to bureaucracy. In 1993, the interbank rate was introduced, replacing the weekly auction, to make the official market more efficient. Since then, market forces of demand and supply determine the exchange rate of the day.

Since then, the economy has grown at an average of 6.65 percent from 1987 to 2014 (see Figure 2.1 below) on account of a number of reforms in almost all sectors of the economy. However, the growth of the economy was not matched by the increase in consumption of electricity due to the negligence and destruction of the infrastructure during the civil wars of the late 1970s and early 1980s.

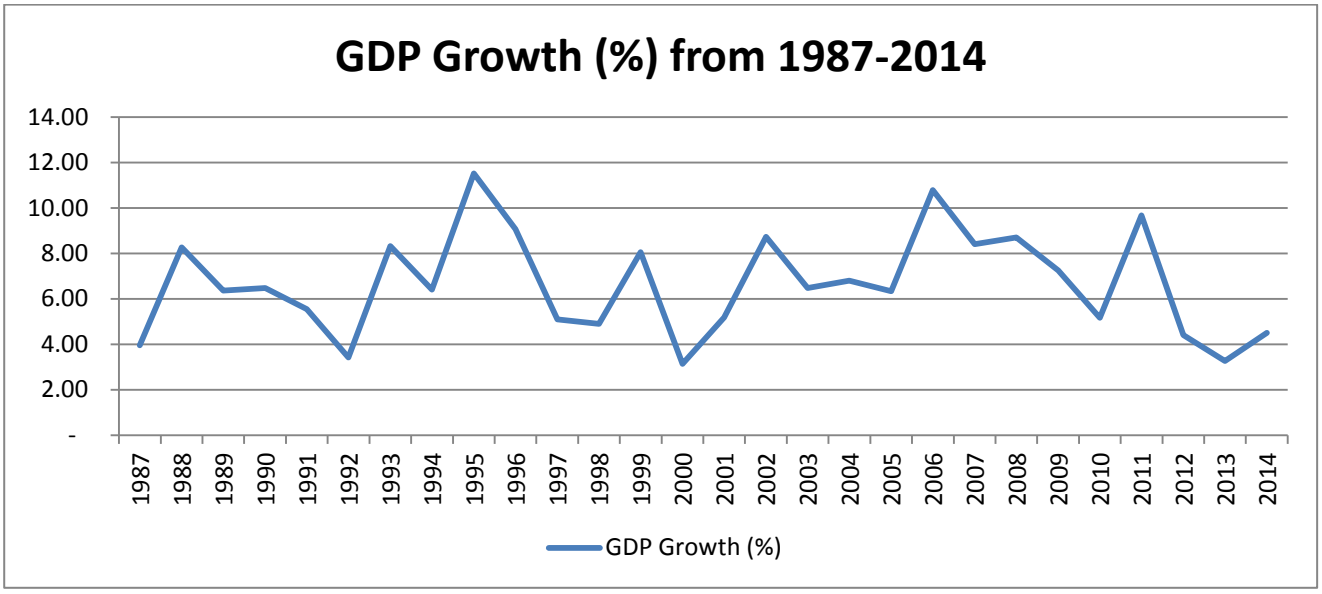

Figure 2.1: Uganda's GDP Growth (%) from 1987–2014

Source: World Bank, 2014

In the early 1990s, the government instituted reforms aimed at reducing sector dependency on subsidies and freeing up resources to other critical areas of the economy. According to Engurait (2005), these reforms were also aimed at attracting investors that could accelerate generation and distribution of electricity in the country. These numerous reforms coupled with political stability have partly contributed to the impressive growth results from the 1990s to date.

2.4 UGANDA'S ELECTRICITY SECTOR AND CONSUMPTION PATTERNS

The main sources of energy in Uganda are biofuel, wood fuel, hydroelectric power, biogas, bagasse, wind and solar energy. Of these, the most exploited is biomass, which consists of wood

fuel and charcoal that are considered cheaper by the majority of Ugandans, especially those in rural and peri-urban areas. In fact, this source accounts for over 93 percent of the total energy consumed in the country, while petroleum products and electricity account for six and one percent respectively (Baanabe, 2012).

Data from the Uganda National Household Surveys (UNHS) shows that the national electrification rate has improved modestly from 9.5 percent in 2002 to 14 percent in 2013 and is one of the lowest in Sub-Saharan Africa, with unequal access rates for urban and rural dwellers. Again, the majority of Ugandans do not have access to electricity, especially the rural households that account for 72 percent of the population (UBOS, 2014). While the urban electrification rate is 40 percent, the rural electrification rate is much lower: in 2013 a whopping 95.6 percent of all rural households did not have access to electricity on the national grid (Mawejje, 2014).

The government of Uganda has been implementing a number of reforms and policies aimed at addressing the country's electricity needs. In 1952, the colonial government started the development of the Owen Falls dam that was commissioned in April 1954. Its commissioning coincided with the establishment of the Uganda Electricity Board (UEB) to manage the generation, transmission and distribution of electricity in the country. At its commissioning, the electricity demand was lower than the initially commissioned capacity of 150 MW that was later increased to 180 MW following increased demand in the late 1980s (Engurait, 2005).

Initially the plan had been to expand the generation capacity of the plant to 180 MW to ignite economic and social transformation of the country. However, as Gore (2009) observed, the anticipated benefits were never realised owing to financial and technical constraints that faced the UEB. Gore stresses that the lack of funds to extend the grid to the rural areas meant that prospective customers were never connected, hence there was no additional revenue but reliance on government subsidies.

The above challenges notwithstanding, the UEB proposed to the government an ambitious plan to increase generation capacity by developing the Bujagali project which was approved in 1965. However, the political turmoil after independence almost brought the whole electricity sector to a standstill. Engurait (2005) notes that during this period, the electricity infrastructure was neglected, the generation capacity fell to below 60 MW and customer numbers fell to below 25 percent of the previous year's connected customers.

In 1993, the NRM government, with support from the World Bank under the Public Enterprise Reform and Divesture (PERD) programme, started implementation of reforms to revive the sector. The major aim of these reforms was to attract more private sector investors which would also improve the efficiency with which the utilities were being run and increased competition and regulation (Mawejje *et al*., 2013).

In 1999, the Electricity Act was promulgated by parliament, providing a legal and regulatory framework for the implementation of reforms in the sector. This Act introduced the Electricity Regulatory Authority as the regulating body for all the electric utilities, the Electricity Tribunal for legal redress, Uganda Electricity Generation Company Limited (UEGCL) responsible for generating electricity, Uganda Electricity Transmission Company Limited (UETCL) responsible for transmitting electricity, and Uganda Electricity Distribution Company Limited (UEDCL) responsible for distribution of electricity. A Rural Electrification Fund (REF) was also set up to fund the rural infrastructure and increase accessibility.

With the introduction of these electricity reforms, a number of private players undertook concessions to run the existing government assets led by Eskom (South Africa) and distribution segments mainly by Umeme Limited, while others took up potential sites to generate electricity.

2.5 CURRENT STATUS OF THE ELECTRICITY SUPPLY INDUSTRY

The unbundling the sector opened up opportunities in the ESI. To date, according to the ERA website, there were 32 licensed and operational companies/utilities in Uganda with twenty three (23) companies in generation, eight (8) companies in distribution and one transmission company. Of the 23 licensed generators, only 13 were already in operation, with ten projects in the construction phase. Table 2.5 shows the electricity generating companies following the liberalisation of the ESI and encouragement of private sector participation. From the table, it can be see that there has been increased investment in the industry, the national access rate has increased, more Ugandans have been connected to the national grid, the investment has increased, the generation capacity has increased, power losses have been reduced and there has been increased operating efficiency.

Table 2.5: Electricity generating companies as at December 2014

Generator	Operator	Technology	Installed Capacity	Available Capacity (2015)
Large Hydro Power Plants				
Bujagali	Bujagali Electricity Company	Hydro	250.0	250.0
Nalubaale and Kiira	Eskom (U) Limited	Hydro	380.0	265.0
Mini-Hydro Power Plants				
Mpanga	AEMS Mpanga	Hydro	18.0	18.0
Bugoye (Mobuku II)	Tronder Power Limited	Hydro	13.0	13.0
Kabalega (Buseruka)	Hydromax Limited	Hydro	9.0	10.0
Ishasha	Eco-Power	Hydro	6.6	3.5
Mobuku 1	Tibet Hima Mining Co Ltd****	Hydro	5.0	5.0
Mobuku III	Kasese Cobalt Company Ltd	Hydro	9.9	10.0
Nyagak**	West-Nile Rural Electricity Co	Hydro	3.5	3.5
Thermals Generators				
Namanve***	Jacobsen (U) Ltd	Thermal	50.0	50.0
Tororo***	Electro-Maxx (U) Ltd	Thermal	86.0	50.0
Co-generation/ Bagasse				
Kakira	Kakira Sugar Ltd	Co-generation	50.0	32.0
Kinyara	Kinyara Sugar Works Ltd	Co-generation	14.5	5.0

Source: ERA ESI database

Notes:

** - Off-grid generation

*** - Plants retained but at a minimum dispatch of 7 MW

**** - Formerly Kilembe Mines Limited

2.6 ELECTRICITY SUPPLY INDUSTRY

The electricity supply industry is characterised by increased investment in the generation of electricity, and increased accessibility following the liberalisation of the sector. Accessibility as well as investment in the sector has increased, while operational and commercial losses and operational inefficiencies reduced from 36 percent in 1990 to 22[1] percent in 2014according to available statistics from ERA[2].

2.6.1 Generation network

The electricity generation in the sector increased from 359 MW in 2010 to 715 MW in 2015 as shown in Figure 2.2. The increased capacity was occasioned by commissioning of electricity generating companies over the years. The number of companies generating power and selling to the transmission grid increased from four companies in 2004 to 12 companies in 2013 (UETCL, 2013).

According to UETCL (2013), the highest composite monthly generated capacity in 2013 was 544 MW compared to the demand of 516 MW, leaving the country with legroom to meet its electricity demands. Electricity generated increased from 202 GWh in 1960 to 2 297 GWh in 2014 on account of increased generation and demand. The recent discovery of oil in the Albertine region will spur industrial development that will require much more electricity to run industries in excess of the current 10–12 percent growth in demand for economic development.

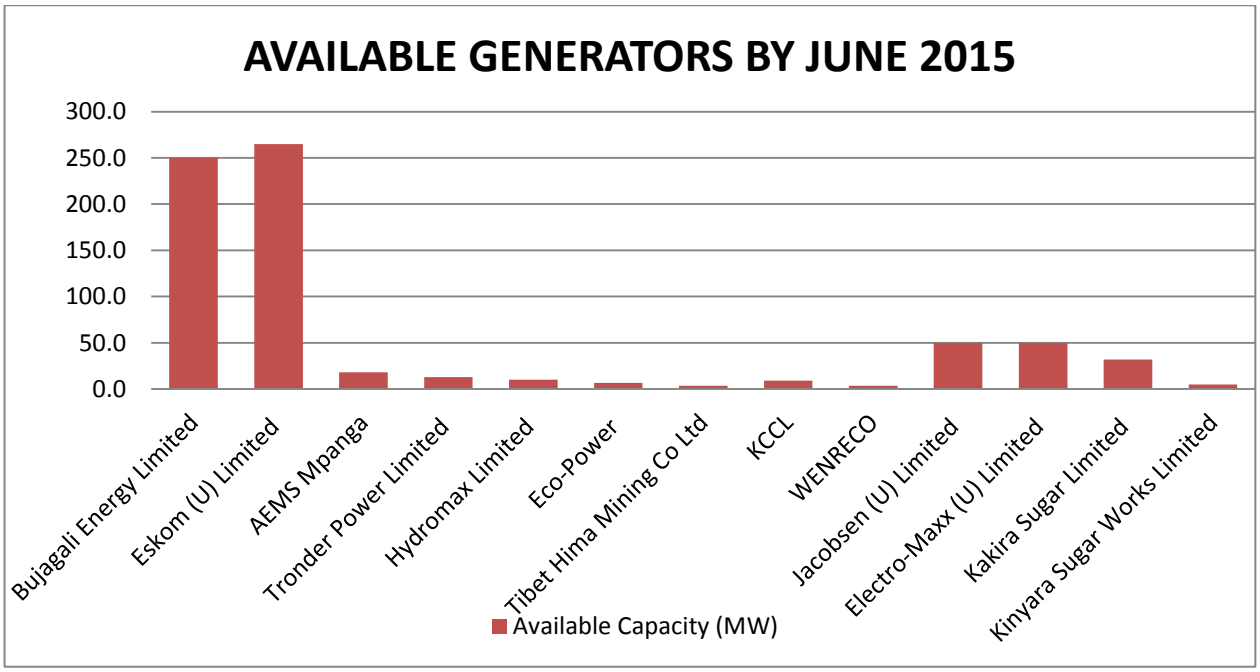

Figure 2.2: Available generation capacity 2015

[1] Loss realisation by Umeme limited a distributor that controls over 99 percent of energy sold in the Country.
[2] http://www.era.or.ug/index.php/statistics-tariffs/2013-11-27-16-54-30

Source: ERA Annual Performance Report, 2015:35

To meet the country's future electricity demand, a number of projects with a total capacity of 241.5 MW have been licensed for construction as shown in Table 2.6. Other projects in the pipeline though not yet licensed are Karuma (600 MW) and Isimba Hydro Power Project (183 MW), both under construction and allocated along the river Nile. In total, the planned generation capacity is expected to be 1 024 MW by the end of 2020.

Table 2.6: Licensed projects under construction

	Company name	Technology	Capacity (MW)
1	Kikagati Power Company Limited	Hydro	16.0
2	South Asia Energy Management Systems LLC	Hydro	9.2
3	Rwimi EP Company Limited	Hydro	5.5
4	Kalangala Infrastructure Services	Solar & Thermal	1.6
5	Elgon Hydro Siti (Pvt) Limited	Hydro	5.0
6	Elgon Hydro Siti (Pvt) Limited	Hydro	16.5
7	Jelco Nengo Hydro Power Company Limited	Hydro	6.7
8	Hydromax (Nkusi) Limited	Hydro	4.8
9	Muvumbe Hydro (U) Limited	Hydro	6.5
10	Lubilia Kawembe Hydro Limited	Hydro	5.4
11	PH Industrial Farms (U) Ltd	Biomass	1.0
12	Butama Hydro Electricity Ltd	Hydro	5.3
13	ARPE Limited	Hydro	83.0
14	Albatros Energy (U) Ltd	Crude Oil	50.0
15	Building Energy SPA	Solar	10.0
16	Access Energy Uganda	Solar	10.0
17	Greenewus Energy Africa Ltd	Hydro	5.0
	Total		**241.5**

Source: ERA Annual Performance Report, June 2015.

2.6.2 Transmission network

From the time of commissioning the first power plant, the role of transmitting power has been with the government. Prior to the unbundling of the sector, UEB generated, transmitted and distributed power to consumers. Upon the unbundling of UEB, the UETCL, a company limited by shares, was formed mainly to own and operate the transmission grid. It is licensed by ERA to own and operate a high level voltage network of 220kV, 132/110kV and 88/66kV and to import and export electricity in the country.

It is the only system operator and a bulk purchaser of electricity, operating a total kilometre length of 1 616 km and 17 substations each of 1 000 MVA capacity across the country (UETCL, 2013). This length is expected to increase to 7 000 km by 2018, with 2 265.5 km already under construction according to the annual report 2013.

In contrast to the other segments in the sector, the transmission infrastructure is fully funded or financially backed by the Government of Uganda and as such there is no private sector participation.

2.6.3 Distribution network

Prior to liberalisation of the sector, UEB managed the distribution segment in addition to managing the other segments. The liberalisation of the industry allowed the private sector to lease assets under a concessional arrangement that were previously owned by the state enterprise. As a result, there have been reduced operational inefficiencies, increased customer connections, a reduction in losses, and increased collection rates while increasing investment in the network.

UEDCL was formed to build, operate and own distribution assets on behalf of the government of Uganda. In 2005, the existing distribution assets were leased to Umeme Limited for a period of 20 years. According to the lease and assignment agreement, at the end of the 20-year period, the government will assess the performance of the company and decide whether to renew the concession or own-operate by itself. Umeme Limited is now listed on both the Uganda and Nairobi Stock Exchanges, and controls over 99 percent of the electricity distributed to the grid.

According to the UEB, 1999, of the power distributed to the grid, 35 percent would not be billed as it ended in illegal connections and a dilapidated network. After Umeme took over the operation of the network with the supervision of the regulator, losses have reduced from 35 percent to 22 percent in 2014 (ERA, 2014, database). Although other players have since come into the market, Umeme still remains the biggest electricity distributor in the country. See Table 2.7.

Table 2.7: Electricity Distribution Companies 2014

Distribution Companies	Sales in kWh	% of Total Energy
Bundibugyo Energy Co-Operative Society	1,565,349	0.00
Ferdsult Engineering Services	14,399,227	0.01
Kilembe Investments Limited	3,280,243	0.00
Pader Abim Community Multipurpose Electric Cooperative Society Limited	1,528,898	0.00
Umeme Uganda Limited	2,276,543,838	0.99
West Nile Rural Electrification Company	6,971,761	0.00
Total	2,304,289,317	100

Source: ERA, 2014 Statistics

Overall, electricity consumption has seen an increasing trend save for the years when the political environment was not favourable for the economy or for consumers. From Figure 2.3 below, it can be seen that the consumption has been on a growing trend after 1987.

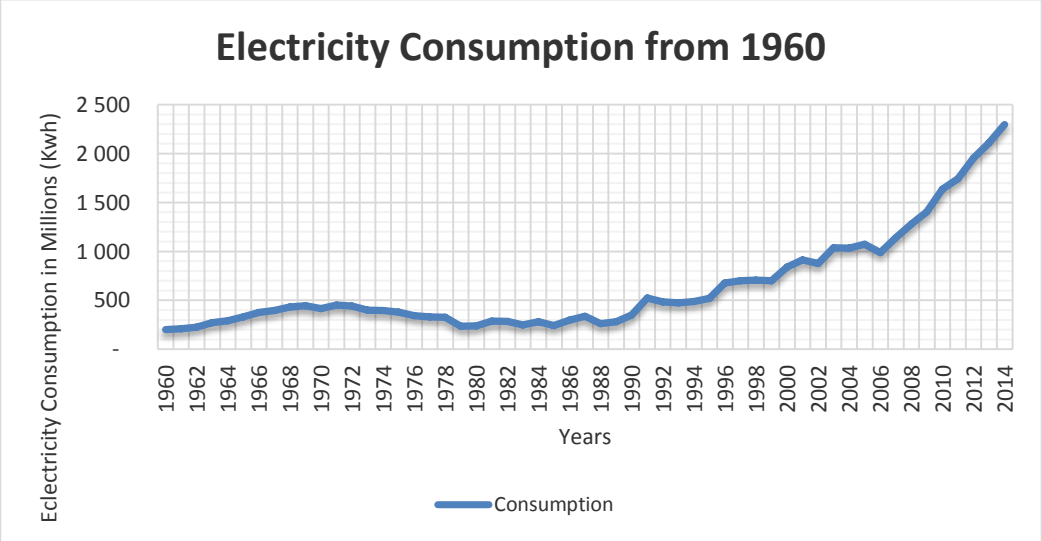

Figure 2.3: Electricity consumption

Source: World Bank, 2015 statistics

The consumption partner above depicts the economic growth trends earlier discussed in figure 2.3 Consumption began to rise in 1960 until 1970 when the Asians were expelled under the Idi Amin regime. The locals who inherited the companies had no experience and skills to operate them and so the companies could no longer operate.

Between 1980 and 1985 shows the lowest level of electricity due to the fragile state of the economy at the time. From 1986, consumption has been on a steady growth trend save for a few challenges that face the sector.

2.7 ELECTRICITY DISTRIBUTION CHALLENGES IN UGANDA

Electricity consumption patterns in Uganda have not been any different from those of many developing countries. Whereas there has been increased investment in the distribution network, electricity consumption is heavily constrained by other factors, including network accessibility and high electricity tariffs.

2.7.1 Accessibility

Electricity access has long been curtailed by the limited electricity supply in the country coupled with the dilapidated network. According to data from the UBOS (2014), the electrification rates improved from 9.5 percent in 2002 to 14 percent in 2013. However, the electrification rates remain the lowest in Sub-Saharan Africa. Furthermore, the accessibility is skewed towards the urban areas . The survey showed that 40 percent of the urban dwellers had access to electricity while 95.6 percent of their rural counterparts did not have access to electricity, further increasing the problem (Mawejje, 2014)

2.7.2 High commercial tariffs

The electricity tariff is adjusted on a quarterly basis to reflect the changes in the economy. For instance, in quarter one of 2015, electricity weighted average tariffs increased to Ushs 328.7 (US$ 9.27 cents) from Ushs 320.5 (US$ 9.04 cents) for industrial consumers while tariff for domestic consumers increased to Ushs 558.4/kWh (US$ 15.74 cents) from Ushs 544.9/kWh[3] (US$ 15.36 Cents). High electricity prices increase the cost of doing business, which reduces disposable income to enhance consumption.

2.8 CONCLUSION

This chapter summarised the history of Uganda's growth and the status of the electricity supply industry in Uganda, starting with the history to the performance of each of the segments of the industry while highlighting a few challenges facing electricity consumption in Uganda. From the discussion, it is clear that had it not been for the political instability that tore the country apart, the economy would have grown much more than it has and the consumption would have been much improved.

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[3] http://www.era.or.ug/index.php/statistics-tariffs/tariffs/distribution-tariffs/2014-10-14-10-24-55

CHAPTER 3
LITERATURE REVIEW

3.1 INTRODUCTION

This chapter provides the theoretical framework in which the study discusses the concepts and analyses the similarities of different researchers on the subject. The chapter also includes a review of relevant literature.

3.2 THEORETICAL FRAMEWORK

Traditionally, economic growth (GDP) is the summation of the country's total output including the value of services. It is the amount of output an economy produces. Functionally, GDP can be expressed as a function of consumption, investment (savings), government expenditure and the net of exports from imports. Mathematically, this can be expressed as:

$$GDP\ (Y) = F(C + I + G + (X - M). \quad \ldots(3.1)$$

It can be demonstrated that Gross Domestic Product (Y) is a function of Consumption (C), Investment (I), Government expenditure (G) and the net of exports and imports (X-M).

This consumption is the aggregate private consumption of both goods and services at both household level and at individual/firms' level. Electricity consumption is part of this aggregate consumption at all levels. According to Keynes (1936), consumption levels increase with an increase in income although the rate of increase between the two variables is different. This presupposes that as the economy continue to grow, the level of consumption in general and electricity in particular should also increase.

The Keynes model of consumption alludes to the fact that the current consumption expenditure is as a result of the current level of disposable income and that the average level of consumption falls as incomes increase. However other theorists, such as Irving Fisher (1965), using the theory of interest, believe that consumers are forward-looking and chose their mode of consumption for the present as well as the future to maximise their lifetime satisfaction. He noted that whereas human beings are limited by present budget constraints, they will always borrow to satisfy current needs.

Fisher differs from Keynes in that Keynes assumes that current consumption depends on current income only, without taking into consideration the timing of incomes, although they agree to some extent that one's income is the main determinant of consumption.

The other two theories on consumption are accredited to Ando & Modigliani (1963) and Milton Friedman (1957). Franco Modigliano's theory, which was later referred to as the Life-Cycle Hypothesis, asserts that income varies systematically throughout the consumer's life cycle which allows him to use his savings to smooth his consumption. This theory assumes that consumers

apportion their resources over their lifetime equally at zero interest rate. Friedman, on the other hand, assumes that consumers use savings and borrowings to smooth consumption. This implies that high income earners have higher temporary incomes than low income earners.

Different theorists have traced the consumption behaviour that dictates the pattern of expenditure by individuals. This research will espouse the Keynes theory as also used by Huang (1993) and recently by Bildirici (2013) to examine its relationship with economic growth movements.

3.3 EMPIRICAL RELATIONSHIP

The empirical relationship between electricity consumption and economic growth elasticity is not a straightforward one. Kraft and Kraft (1978) used Granger causality on the annual U.S. annual statistics from 1947-1974 to establish the relationship between electricity consumption and Gross National Product (GNP). They observed that the relationship runs from economic growth to electricity consumption, meaning that increasing GNP led to increased electricity consumption in the periods under review.

Since then, several researchers have analysed this relationship. These include Murry and Nan (1996) on 23 developed and developing countries across the globe, Wolde-Rufael (2006) for 17 African countries, and Chen, Kuo, & Chen (2007) for 10 Asian countries. Other studies have focused on individual country analysis, for instance Yang (2000) for Taiwan, Aqueel and Butt (2001) for Pakistani, Jumbe (2004) for Malawi, Wolde-Rufael (2004) for Shangai, Tang (2008) for Malaysia, Yuan, Kang, Zhao & Hu (2008) for China, Ghosh (2002) for India, Odhiambo (2009a) for Tanzania and Odhiambo (2009b) for South Africa.

Although a number of studies have been done around the world, only a handful have been conducted in Africa, and specifically in Sub-Saharan Africa, compared to Asia and Latin America (Odhiambo, 2009a). In Africa, the few studies have output divergent conclusions to make one rely on data in one country to explain the specifics in another country.

For instance, Akinlo (2008) and Jumbe (2004) examined the relationship between electricity consumption and economic growth for Ghana and Malawi respectively. They both used Granger causality and their findings showed a bi-directional relationship in the respective countries. However, Odhiambo (2014) and Odhiambo (2009b) ran the same variables using the same methodology, and conclude that the relationship that existed was a unidirectional relationship running from economic growth to electricity consumption for Ghana and from electricity to economic growth for Malawi. Although the periods of study were different, this further shows how dynamic this relationship could be.

3.4 CAUSALITY RELATIONSHIP

The electricity consumption and economic growth nexus has been studied by different authors and is therefore not a new one. Kraft and Kraft (1978) and Akarca and Long (1980) looked at the US economy using causality techniques to establish the existence and kind of relationship. The general observation from these studies is that the relationship between electricity consumption and economic growth is not a straightforward one.

Studies conducted in various countries worldwide, such as Bowden and Payne (2009) in the USA, Ho and Siu (2007) in Hong Kong, Oh and Lee (2004) in Korea, and Odhiambo (2009a) in Tanzania all concluded that electricity consumption Granger-causes economic growth and not vice versa. On the other hand, Ghosh (2002) India, Halicioglu (2007) Turkey, Hu and Lin (2008) Taiwan, examined the same relationship and observed a causality running from GDP to electricity consumption. Wolde-Rufael (2006) observed a neutrality relationship between the two variables for Algeria, Congo Republic, Kenya, South Africa and Sudan using the Yoda-Yamamoto causality test on data spanning a period of 30 years from 1971–2001.

It can therefore be noted that whereas all the above studies have observed existence of a relationship, the direction of that relationship is what matters to guide future decision making. Ozturk (2010) and Payne (2010) identified over sixty and forty papers respectively focusing on this relationship both in specific countries and panel data studies. Their observations delivered results that belonged in any of the three relationships:

a) Unidirectional causality, where electricity consumption causes an increase in GDP or increased GDP contributes strongly to an increase in electricity consumption. The outcomes of this unidirectional causality could be *conservative hypothesis/consumption led growth or growth hypothesis-growth led consumption hypothesis*.
b) Bi-directional causality (BD), where electricity consumption increases as a result of increased economic growth and *vice versa*.
c) The absence of causality (AC) at all, that is to say that increasing electricity consumption leaves growth the same and the increased economic growth does not lead to increased electricity consumption.

Several studies have confirmed the existence of one of these above relationships. Narayan, Smyth and Prasad (2007) have confirmed a unidirectional causality running from electricity consumption to economic growth for Australia, Hungary, Slovak Republic, Czech Republic using specific country data for 42 years. In Africa, Wolde-Rufael (2006) confirmed the same causality relationship using the Yoda-Yamamoto causality method with the respective data for a period of 30 years from 1971 to 2001 for Benin, Congo Democratic Republic and Tunisia. The same results were observed by Odhiambo (2010) using the ARDL Bounds Testing procedure for Kenya and South Africa, Belloumi

(2009) on Tunisia using the Vector Error Correction Model (VECM), and Al-mulali and Sab (2012) on 30 Sub-Saharan African countries using the Panel Cointegration Causality test. Other studies include Odhiambo (2009a) for Tanzania where the same results were confirmed using the ARDL-Bounds Testing Procedure.

Recent research findings from Solarin and Shahbhaz (2013) for Angola using the ARDL-Bounds Testing procedure and VECM Causality test, and Ouedraogo (2013) for 15 ECOWAS (Economic Community for West African States) countries using the panel cointegration causality tests have corroborated the earlier finding of this causality relationship.

Table 3.1: Selected studies on conservative hypothesis (consumption-led growth hypothesis)

Author(s)	Countries Studied	Period	Methodology	Findings
Yu and Choi (1985)	United States (US), United Kingdom, Poland, Korea, Philippines	1950–1976	Granger Causality	$ec \rightarrow gdp$ For Korea and Philippines
Murry and Nan (1996)	Canada, Colombia, El Salvador, France, Germany, Hong Kong, India, Indonesia, Israel, Kenya, Luxembourg, Malaysia, Mexico, Norway, Pakistan, Philippines, Portugal, Singapore, South Korea, Turkey, United Kingdom, United States, Zambia	1970–1990 Actual results	Granger Causality; Vector Auto Regression (VAR)	$ec \rightarrow gdp$; For Canada, Hong Kong, Pakistan, Philippines, Singapore and Turkey.
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore and Philippines	Various periods	Vector Error Correction Model (VECM)	$ec \rightarrow gdp$
Yang (2000)	Taiwan	1954–1997	Granger Causality	$ec \rightarrow gdp$
Asafu-Adjaye (2000)	India, Indonesia, Thailand	Various periods	Vector Error Correction Model	$ec \rightarrow gdp$: For India and Indonesia
Aqeel and Butt (2001)	Pakistan	1955–1996	Engle-Granger; No Cointegration; VAR	$ec \rightarrow gdp$
Soytas and Sari (2003)	Argentina, Italy, Korea, Turkey, France, Germany, Japan	1950–1992	Cointegration and Granger Causality	$ec \rightarrow gdp$ for Turkey, France, Germany and Japan.

Author(s)	Countries Studied	Period	Methodology	Findings
Fatai, Oxley,& Scrimgeour (2004)	Indonesia, India, Thailand, Philippines	1960–1999	Bivariate Toda-Yamamoto	$ec \rightarrow gdp$ For Indonesia and India.
Wolde-Rufael (2004)	Shanghai	1952–1999	Yoda-Yamamoto causality	$ec \rightarrow gdp$
Shiu and Lam (2004)	China	1971–2000	Johansen-Juselius; Cointegration: VECM	$ec \rightarrow gdp$
Morito and Hope (2004)	Sri Lanka	1960–1998	Granger Causality	$ec \rightarrow gdp$
Altinay and Karagol (2005)	Turkey	1950–2000	Dolado-Lutkepohl causality	$ec \rightarrow gdp$
Lee and Chang (2005)	Taiwan	1950–2000	Johansen-Juselius; Cointegration VEC	$ec \rightarrow gdp$
Lee (2005)	Argentina, Chile, Colombia, Singapore, Hungary, Mexico, Peru, Indonesia, Malaysia, Philippines, Venezuela, Thailand, India, Sri Lanka, Ghana, Kenya, South Korea, Pakistan	1975–2001	Panel Cointegration	$ec \rightarrow gdp$
Wolde-Rufael (2006)	17 African countries	1971–2001	ARDL-Bounds Testing Procedure	$ec \rightarrow gdp$ For Benin, DR Congo and Tunisia
Ho and Siu (2007)	Hong Kong	1966–2002	VECM	$ec \rightarrow gdp$
Chen (2007)	Hong Kong, Indonesia, India, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand	1971–2001	Cointegration; VECM	$ec \rightarrow gdp$ For Indonesia.
Mahadevan and Asufu-Adjaye (2007)	20 Net importing and exporting countries	1971-2002	Panel Error Correction Model	$ec \rightarrow gdp$ For Argentina, Indonesia, Kuwait, Malaysia, Nigeria, Saudi

Author(s)	Countries Studied	Period	Methodology	Findings
				Arabia and Venezuela.
Yuan *et al*. (2007)	China	1978–2004	Johansen-Juselius; Cointegration VEC	$ec \rightarrow gdp$
Narayan and Singh (2007)	Fiji Islands	1971–2002	ARDL-Bounds Testing Procedure	$ec \rightarrow gdp$
Akinlo (2008)	Cameroon, Côte d'Ivoire, Congo, Gambia, Ghana, Kenya, Nigeria, Senegal, Sudan, Togo and Zimbabwe	1980–2003	Granger Causality based on VECM	$\mathrm{ec} \rightarrow \mathrm{gdp}$ for Ghana, Kenya and Senegal
Akinlo (2009)	Nigeria	1980–2006	VECM	$ec \rightarrow gdp$
Wolde-Rufael (2009)	17 African countries	1971–2004	Multivariate Causality	$ec \rightarrow gdp$ for Algeria, Benin and South Africa
Odhiambo (2009a)	Tanzania	1971–2006	ARDL bounds test; Cointegration; VECM	$ec \rightarrow gdp$
Belloumi (2009)	Tunisia	1971–2004	VECM	$ec \rightarrow gdp$ In the Short run
Tsani (2010)	Greece	1960–2006	Yoda-Yamamoto Causality test	$ec \rightarrow gdp$
Odhiambo (2010)	DR Congo, Kenya and South Africa	1972–2006	ARDL-Bounds testing procedure	$ec \rightarrow gdp$ For South Africa and Kenya.
Apergis and Payne (2010)	9 South American countries	1980–2005	Panel Cointegration	$ec \rightarrow gdp$
Al-mulali and Sab (2012)	30 Sub-Saharan African countries	1980–2008	Panel cointegration causality test	$ec \rightarrow gdp$
Ouedraogo (2013)	15 ECOWAS countries	1980–2008	Panel Cointegration Causality Tests	$ec \rightarrow gdp$ Long term
Shahbhaz *et al.* (2013)	China	1971–2011	ARDL-Bounds testing procedure	$ec \rightarrow gdp$

Author(s)	Countries Studied	Period	Methodology	Findings
Solarin and Shabbhaz (2013)	Angola	1971–2009	ARDL-Bounds Test; VECM Causality test	$ec \rightarrow gdp$

Where → symbol denotes a unidirectional relationship running from electricity consumption (ec) to economic growth (gdp), ARDL = Autoregressive Distributed Lag, VECM = Vector Error Correction Model, VEC = Vector Error Correction and VAR = Vector Auto regression.

On the other hand, other research findings have confirmed the existing of a unidirectional causal relationship running from growth to electricity consumption (growth hypothesis). According to Oztuk (2010), this relationship confirms that failure to increase the amount of electricity available in a country will adversely affect economic growth. This hypothesis holds that electricity consumption plays an important role in the growth of an economy both directly and indirectly through enhancing the production process.

Wolde-Rufael (2006) confirmed this causal relationship for six of the 20 African countries studied (Cameroon, Gabon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe) using the Yoda-Yamamoto causality test on data spanning a period of 30 years. Other studies, such as Chen *et al.* (2007), confirmed this kind of relationship in Indonesia, Al-Iriani (2006) for the Gulf co-operation countries in Asia, and Kraft and Kraft (1978) for the USA.

Recent studies have also confirmed existence of this hypothesis. These studies include Iyke & Odhiambo (2014) for Ghana, Ouedraogo (2013) for 15 ECOWAS countries, and Stern and Enflo (2013) for Sweden. The growth-led hypothesis gives policy makers alternative reasons for growth other than increasing electricity consumption.

Table 3.2: Selected studies on the growth hypothesis (growth-led consumption hypothesis)

Author(s)	Countries Studied	Period	Methodology	Findings
Kraft and Kraft (1978)	US	1947–1974	Granger Causality	$gdp \rightarrow ec$
Yu and Choi (1985)	South Korea and Philippines	1954–1976	Standard Granger Causality	$gdp \rightarrow ec$ for South Korea
Murry and Nan (1996)	Canada, Colombia, El Salvador, France, Germany, Hong Kong, India, Indonesia, Israel, Kenya, Luxembourg,	1970–1990 Actual results	Granger Causality; Vector Auto Regression (VAR)	$gdp \rightarrow ec$ For Colombia, El Salvador, Indonesia, Kenya and

Author(s)	Countries Studied	Period	Methodology	Findings
	Malaysia, Mexico, Norway, Pakistan, Philippines, Portugal, Singapore, South Korea, Turkey, United Kingdom, United States, Zambia			Mexico.
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore, the Philippines	Various periods	VECM	$gdp \rightarrow ec$
Cheng and Lai (1997)	Taiwan	1954–1993	Granger Causality	$gdp \rightarrow ec$
Aqeel and Butt (2001)	Pakistan	1955–1996	Cointegration, Granger Causality	$gdp \rightarrow ec$
Ghosh (2002)	India	1950–1997	Engle- Granger Causality; VAR	$gdp \rightarrow ec$
Wolde-Rufael (2004)	Shanghai	1952–1999	Granger Causality	$gdp \rightarrow ec$
Narayan and Smyth (2005)	Australia	1966–1999	ARDL Bounds Testing	$gdp \rightarrow ec$
Al-Iriani (2006)	Gulf co-operation countries	1971–1999	Panel Cointegration and Panel Causality Test	$gdp \rightarrow ec$
Yoo (2006)	Indonesia, Malaysia, Singapore, Thailand	1971–2002	Johansen-Juselius, no cointegration; VAR	$gdp \rightarrow ec$ for Indonesia and Thailand
Chen (2007)	Hong Kong, Indonesia, India, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand	1971–2001	Cointegration; VEC	$gdp \rightarrow ec$ For India, Korea, Malaysia, Philippines, Singapore.
Mozumder and Marathe (2007)	Bangladesh	1971–1999	Johansen-Juselius, no cointegration; VAR	$gdp \rightarrow ec$
Hu and Lin (2008)	Taiwan	1981Q1–2006Q4	Hansen-Seo threshold cointegration; VEC	$gdp \rightarrow ec$
Akinlo (2008)	Cameroon, Côte d'Ivoire,	1980–2003	Granger Causality based	$gdp \rightarrow ec$ for

Author(s)	Countries Studied	Period	Methodology	Findings
	Congo, Gambia, Ghana, Kenya, Nigeria, Senegal, Sudan, Togo and Zimbabwe		on VECM	Sudan and Zimbabwe
Zhang and Cheng (2009)	China	1960–2007	Yoda-Yammamoto Test	$gdp \rightarrow ec$
Wolde-Rufael (2009)	17 African countries	1971–2004	Multivariate Causality	$gdp \rightarrow ec$ Egypt, Côte d'Ivoire, Morocco, Nigeria, Senegal, Sudan, Sudan, Tunisia and Zambia
Ouedraogo (2013)	15 ECOWAS countries	1980–2008	Panel Cointegration Causality test	$gdp \rightarrow ec$
Stern and Enflo (2013)	Sweden	1950–2000	Granger Causality	$gdp \rightarrow ec$

Where → symbol denotes a unidirectional relationship running from economic growth (gdp) to electricity consumption (ec), ARDL = Autoregressive Distributed Lag, VECM = Vector Error Correction Model, VEC = Vector Error Correction and VAR = Vector Auto regression.

The findings from other empirical studies have observed with a bi-directional causality relationship, which is also termed *feed-back hypothesis*. Studies by Yang (2000), Shahbaz, Tang & Shabbir (2011) and Mutascu, Shahbaz & Tiwari (2011) in different country studies of Pakistan, Portugal and Romania using the Granger causality model have confirmed this kind of relationship.

These results however, are not static. Different researchers have had different results using relatively the same data. For instance, Aqeel and Butt (2001) used Hsiao's version of the Granger Causality method and co-integration, and found a unidirectional causality from GDP to economic growth in Pakistan, and when Shahbaz & Lean (2012) examined the same relationship, a bi-directional granger causality relationship was observed. Some of the selected study results with this relationship are presented in Table 3.8 below.

Table 3.8: Selected studies on bi-directional causality (feedback hypothesis)

Author(s)	Countries Studied	Period	Methodology	Findings
Erol and Yu (1987)	West Germany, Italy, Canada, France, UK, Japan	1952–1980 and 1982	Granger Causality	$ec \leftrightarrow gdp$ Japan
Hwang and Gum (1991)	Taiwan	1961–1990	Cointegration Granger Causality	$ec \leftrightarrow gdp$
Glasure and Lee (1998)	Singapore and South Korea	1961–1990	Bivariate Vector Error Correction Model	$ec \leftrightarrow gdp$
Yang (2000)	Taiwan	1954–1997	VAR; Engle Granger Causality	$ec \leftrightarrow gdp$
Asafu-Adjaye (2000)	India, Indonesia, Philippines, Thailand	1973–1995 1971–1995	Cointegration and Granger Causality based on ECM	$ec \leftrightarrow gdp$ Philippines and Thailand.
Glasure (2002)	South Korea	1961–1990	Cointegration, error-correction, variance decomposition	$ec \leftrightarrow gdp$
Soytas and Sari (2003)	Argentina, Italy, Korea, Turkey, France, Germany, Japan	1950–1992	Cointegration and Granger Causality	$ec \leftrightarrow gdp$ Argentina.
Ghali (2004)	Canada	1961–1997	Cointegration, Granger Causality	$ec \leftrightarrow gdp$
Jumbe (2004)	Malawi	1970–1999	Cointegration, Granger Causality and Error Correction	$ec \leftrightarrow gdp$ on Granger Causality and $gdp \leftrightarrow ec$ using Error Correction test.
Oh and Lee (2004)	South Korea	1981Q1–2000 Q4	Vector Error Correction Model	$ec \leftrightarrow gdp$
Wolde-Rufael (2006)	17 African countries	1971–2001	ARDL-Bounds Testing Procedure	$ec \leftrightarrow gdp$ Egypt, Gabon and Morocco.
Mahadevan and Asufu-	20 Net importing and	1971–2002	Panel Error Correction	$ec \leftrightarrow gdp$ Japan, Norway, Australia,

Author(s)	Countries Studied	Period	Methodology	Findings
Adjaye (2007)	exporting countries		Model	US, UK and Sweden.
Akinlo (2008)	Cameroon, Côte d'Ivoire, Congo, Gambia, Ghana, Kenya, Nigeria, Senegal, Sudan, Togo and Zimbabwe	1980–2003	Granger Causality based on VECM	$ec \leftrightarrow gdp$ Ghana, Gabon, Senegal.
Wolde-Rufael (2009)	17 African countries	1971–2004	Multivariate Causality	$ec \leftrightarrow gdp$ Ghana, Gabon, Togo and Zimbabwe.
Odhiambo (2009b)	South Africa	1971–2004	Trivariate Granger Causality	$ec \leftrightarrow gdp$
Belloumi (2009)	Tunisia	1971–2004	Vector Error Correction Model	$ec \leftrightarrow gdp$
Tsani (2010)	Greece	1960–2006	Yoda-Yamamoto Causality test	$ec \leftrightarrow gdp$
Pao and Tsai (2010)	Brazil, Russia, China and India	1965–2009	Granger Causality	$ec \leftrightarrow gdp$
Zhang (2011)	Russia	1970–2008	Yoda-Yamamoto	$ec \leftrightarrow gdp$
Wesseh and Zoumara (2012)	Liberia	1980–2008	Bootstrapped Causality test	$ec \leftrightarrow gdp$
Fuinhas and Marques (2012)	Italy, Greece, Portugal, Spain and Turkey	1965–2009	ARDL-Bounds Testing Procedure	$ec \leftrightarrow gdp$ all countries analysed.
Dagher and Yacoubian (2012)	Lebanon	1980–2009	Hsiao, Toda-Yamamoto and ECM Based Causality Tests.	$ec \leftrightarrow gdp$
Stern and Enflo (2013)	Sweden	1950–2009	Granger Causality Cointegration Test	$ec \leftrightarrow gdp$
Amusa and Leshoro (2013)	Botswana	1981–2010	ARDL-Bounds Testing Procedure	$ec \leftrightarrow gdp$

Author(s)	Countries Studied	Period	Methodology	Findings
Solarin and Shahbaz (2013)	Angola	1971–2009	ARDL-Bounds Testing; Vector Error Correction Model Causality Test.	$ec \leftrightarrow gdp$

Where $\leftrightarrow$ denotes a bi-directional (feedback) relationship between electricity consumption (ec) and economic growth (gdp)

Scholars, for instance Akpan and Akpan (2012), Akarca and Long (1980), Karanfil (2008) and Yu and Choi (1985), found no causality in Nigeria, USA, Turkey, and five countries studied by Yu and Choi. This causality is also known as the *neutrality hypothesis*, and implies that the electricity consumption trend is not related to GDP growth trend. In other words, policies aimed at electricity consumption increase or curtailing do not affect the growth of the economy. This hypothesis is supported by the absence of a causal relationship in the data analysed for Algeria, Congo Republic, Kenya, Sudan and South Africa by Wolde-Rufael (2006). Table 3.4 shows studies finding no causality relationship.

Table 3.4: Selected studies showing no causality relationship (neutrality hypothesis**)**

Author(s)	Countries Studied	Period	Methodology	Findings
Yu and Hwang (1984)	US	1947-1979	Sim's technique	$gdp \neq ec$
Yu and Choi (1985)	US, UK, Philippines Poland, Korea	1950-1976 1954-1976	Granger Causality	$gdp \neq ec$
Stern (1993)	USA	1947-1990	Granger Causality	$gdp \neq ec$
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore, the Philippines	Various periods	VECM	$gdp \neq ec$ Malaysia, Singapore and Philippines.
Glasure and Lee (1997)	South Korea and Singapore	1961-1990	Cointegration, Granger Causality	$gdp \neq ec$ for South Korea.
Soytas and Sari (2003)	Argentina, Italy, Korea, Turkey, France, Germany, Japan	1950-1992	Cointegration and Granger Causality	$ec \neq gdp$ for Canada, Indonesia, Poland, USA and UK.
Wolde-Rufael (2006)	17 African countries	1971-2001	ARDL-Bounds Testing Procedure	$ec \neq gdp$ for Algeria, Kenya, Congo, South

Author(s)	Countries Studied	Period	Methodology	Findings
				Africa and Sudan
Akinlo (2008)	Cameroon, Côte d'Ivoire, Congo, Zambia, Ghana, Kenya, Nigeria, Senegal, Sudan, Togo and Zimbabwe	1980-2003	Granger Causality based on VECM	$ec \neq gdp$ for Cameroon, Côte d'Ivoire, Nigeria, Kenta and Togo.
Wolde-Rufael (2009)	17 African countries	1971-2004	Multivariate Granger Causality	$ec \neq gdp$ for Cameroon and Kenya.
Acaraci and Ozturk (2010)	Turkey	1968-2005	ARDL Bounds Testing Procedure	$ec \neq gdp$
Ozturk and Acaravci (2011)	11 Middle East and North Africa (MENA)	1971-2006	ARDL Bounds Testing Procedure	$ec \neq gdp$

Where ≠ denotes no existence of any relationship

3.5 SPECIFIC STUDIES IN SUB-SAHARAN AFRICA

Studies have been done on a number of countries in Sub-Saharan Africa with conflicting results. Different research studies done on some economies within Sub-Saharan Africa have been identified and discussed as discussed below.

Akomolafe & Danladi, (2014) investigated the causality relationship between electricity consumption and economic growth in Nigeria between 1990 and 2011 using a series of tests including Augmented Dickey Fuller test, Phillip Perron Unit root test, Johansen test for cointegration, VEC and Granger Causality test to confirm the relationship. The results showed a unidirectional causality running from electricity consumption to real GDP.

Prior to Akomolafe, Akinwale, Jesuleye & Siyanbola (2013) had examined this kind of relationship, also in Nigeria, for the period between 1970 and 2005. The study employed Augmented Dickey Fuller test, Vector Auto Regression (VAR) and Error Correction Model (ECM) Causality test the causality relationship. The results showed a unidirectional causality from real GDP to electricity consumption.

In Kenya, Odhiambo (2010) investigated the causal relationship between the two variables using data between 1972 and 2006. The study employed cointegration and error correction models to determine the causal nexus. The results revealed a unidirectional causal relationship running from electricity consumption to economic growth. The study further concluded that electricity

consumption is a solution for economic growth in Kenya and that any electricity conservation policies should be treated with caution.

Studies above have shown different relationships on the causality between electricity consumption and economic growth. While some studies such as Jumbe (2004) for Malawi and Amusa and Leshoro (2013) for Zimbabwe have observed a bi-directional relationship, other studies have not shown no causality relationship at all. This further complicates the estimation of direction of the causality relationship without a full study on the consumption and growth trends.

Odhiambo (2010) examined this nexus in neighboring Kenya using the Granger causality model where the results showed a growth hypothesis. Odhiambo (2009a) did a similar study in Tanzania and the same result was found. However, a similar study conducted in South Africa (Odhiambo (2009b) using the same methodology found bidirectional causality between electricity consumption and economic growth. This shows that results from different countries can be conflicting and at times different and mixed even when the same methodology is applied.

In such situations, it is important to employ multivariate models to investigate the kind of relationship rather than trying another model. Furthermore, the emergency of conflicting results in the same country could be explained by different periods analysed, methods used for cointegration and other variables including energy policy and institutional frame works (Ozturk, 2010).

3.6 CONCLUSION

From the available literature, the relationship between electricity consumption and economic growth is mixed from one country to another. For Uganda, the relationship has never been investigated. As a result, this study aims at determining the relationship that exists between electricity consumption and economic growth in Uganda and examine whether the country needs to focus on electricity consumption as a driver to economic growth.

C H A P T E R 4
M E T H O D O L O G Y

4.1 INTRODUCTION

This chapter introduces a discussion on the source of data and estimation methodology intended to meet the objectives of the study. Section 4.1 discusses the type and source of data in the research report, Section 4.2 describes the data selection method and the sample size, while Sections 4.3 to 4.5 discuss the approaches engaged in obtaining reliable estimates including the econometric modelling techniques and estimates.

4.2 DATA TYPE AND SOURCE

This study uses secondary data on electricity consumption obtained from ERA database from 2001Q2-2014 and the Uganda Electricity Board (UEB) Report and Accounts for 1999. The consumption for the year 2000 has been extracted from the Annual Report of the Ministry of Energy and Mineral Development (MEMD) for the financial year ended June 2000. These publications are publicly available in the ERA and MEMD libraries. Data on Uganda's GDP has been extracted from the World Bank website annualised from 1960 to 2014. These variables are presented as kWh units and USD values for electricity consumption and economic growth.

4.3 ECONOMETRIC MODEL

The theoretical literature on estimation of relative change in electricity consumption as a result of increase in total GDP was pioneered by John Keynes in the 1950s. This theory was later modified by Fisher (1965) in his theory of interest in early 1965. As discussed earlier, the model assumes that today's consumption expenditure is as a result of today's disposable income. The mathematical model can be theoretically expressed as below;

$$ec_t = f(ec_{t-1}, gdp_{t,}\, gdp_{t-1}) \quad \ldots(4.1)$$

Where,

gdp_t is the GDP,

ec_t Cumulative electricity consumption and

$a, b\ and\ c$ are the parameters for the equation with b being used in estimating the income elasticity in Equation 4.1. The above mathematical model cannot however be used to provide the relationship between electricity consumption and economic growth.

To estimate the relationship, researchers use either the ARDL bounds-testing procedure proposed by Pesaran and Shin (1998) or Yoda-Yamamoto (1995) or Dolado-Lutkepohl (1996) to run long-

term causality relationships. Whereas there are a number of approaches to this kind of relationship, the ARDL is the preferred procedure because it performs well with both small and large samples which is usually the case with electricity consumption and economic growth literature. Furthermore, the use of ARDL is preferred because it can simultaneously test short- and long-run relationships between the variables.

4.4 EMPIRICAL MODEL

From the theoretical and as well as the empirical literature, the study will adopt the use of ARDL testing model adopted by Pesaran and Shin (1998) because of the benefits highlighted above. In examining the relationship between electricity consumption and economic growth in Uganda, I adopt time-series econometric methods. In particular, I employ the Auto Regressive Distributed Lag (ARDL) bounds testing methods and Granger Causality testing.

4.4.1 ARDL bounds testing methods

The ARDL bounds testing methods developed by Pesaran, Shin and Smyth (2001), was used in this study to examine the long-run cointegration relationship for between electricity consumption and economic growth in Uganda. The major drawback of the ARDL procedure is that it assumes the existence of a single cointegrating relationship. There are several alternative methods for conducting cointegration analysis, including the maximum likelihood based Johansen (1988) procedure and the residual based Engle-Granger (1987) two-step estimation procedures. However, the major disadvantage of the Johannsen (1998) procedure is that it requires all variables to follow I(1) processes. However, the ARDL has been shown to provide consistent estimates of the long-run coefficients that are asymptotically normal irrespective of whether the underlying regressors are I(1) or I(0) (Pesaran & Shin, 1998). In addition the ARDL approach allows for sufficient numbers of lags to capture the data generating process in a general-to-specific modelling framework. The ARDL model used in this study is expressed as:

$$\Delta lnGDP_t = \alpha_0 + \alpha_1 \Delta lnGDP_{t-i} + \alpha_2 \Delta lnELEC_{t-i} + \alpha_3 lnGDP_{t-1} + \alpha_4 lnELEC_{t-1} + \varepsilon_t \quad \ldots(4.2)$$

Where:

Δ Represents the difference operator

$\ln$ Represents the natural logarithm operator

GDP Represents real GDP

ELEC Represents electricity consumption

ε_t Represents a white noise error term

There are two benefits of representing data in natural logarithm form: first, log transformations smooth the data series, and second, the regression coefficients can be interpreted as elasticities.

The ARDL bounds testing procedure is based on the Wald or the joint F-statistic for the long-run parameters α_3 and α_4 whose joint significance implies a valid long-run relationship among variables. The cointegration test, therefore, is based on the F-test $\alpha_3 = \alpha_4 = 0$. Significance of the joint F-statistic implies cointegration.

Pesaran et al. (2001) provide the asymptotic distribution of the F-statistics under the null hypothesis of no cointegration. The critical values have two sets: one set assumes that all variables included in the ARDL model follow an I (0) process while the other set is calculated on the assumption that variables are I (1). If the computed Wald/F-statistic test statistic is greater than the upper critical bounds then the null hypothesis of no cointegration is rejected; the null hypothesis of no cointegration cannot be rejected if the computed value is lower than the lower bounds value; the test is inconclusive if the statistic falls within the bounds.

4.4.2 Granger causality

After determining the validity of the long-run relationship using the ARDL methods, the next step is to examine the short- and long-run Granger causality between electricity consumption and GDP growth. A variable, say X_t , is said to Granger cause another variable, say Z_t , if, given the past information or values of Z_t, past values of X_t are useful in predicting Z_t (Granger, 1969). A convenient way for testing Granger causality is to regress Z_t on its owned lagged values and on lagged values of X_t and test for the joint significance of the estimated coefficients on lagged coefficients of X_t.

The Granger causality tests adopted in this paper involve testing the null hypothesis that a variable, say X_t, does not Granger cause another variable, say Z_t ,by estimating the two simple models as expressed in equations 4.3 and 4.4:

$$Z_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} Z_{t-i} + \sum_{i=1}^{k} \alpha_{2i} X_{t-i} + \varepsilon_t \; 2) \qquad \ldots(4.3)$$

$$X_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} X_{t-i} + \sum_{i=1}^{k} \beta_{2i} Z_{t-i} + \mu_t \; 3) \qquad \ldots(4.4)$$

Where ε_t and μ_t are white noise disturbance processes. It therefore follows that the Granger causality tests are based on the joint significance of the coefficients α_{2i} and β_{2i} in equations 4.3 and 4.4 above respectively. For example, the null hypothesis that X_t does not Granger cause Z_t is rejected if the coefficients α_{2i} are jointly significant.

4.5 CONCLUSION

This chapter describes the source and type of data used in the study to estimate the method to meet the set objectives. Chapter 5 will analyse the results obtained from the above data sets using the method described in Chapter 4.

CHAPTER 5
PRESENTATION AND DISCUSSION OF FINDINGS

5.1 INTRODUCTION

This chapter presents the analysis of data collected with respect to economic growth and electricity consumption in Uganda. The data has the GDP values and electricity consumption units from 1960 to 2014. The analysis focuses on the relationship between electricity consumption and economic growth.

5.2 DATA DESCRIPTION

The study adopts the time series data in examining this relationship. Annual data from two sources, spanning a 55 year period from 1960 to 2014 was used. In this report, the GDP data was obtained from the World Bank online dataset of development indicators. Electricity data was obtained from the Electricity Regulatory Authority of Uganda.

This data is based on annual data that are publicly available from 1960 to 2014. After data extraction, it is important to test the characteristics of data for stationarity to reduce the possibilities of getting spurious results. There are a number of procedures to follow in testing data properties, including DF-GLS test for a Unit Root Test, Augmented Dickey-Fuller Unit Root Test (ADFL) and Phillips-Perron Unit Root Test. All the three procedures give relatively the same results.

The specific data used is as follows: LNGDP is the natural logarithm of real GDP and LNELEC is the natural logarithm of electricity consumption. The descriptive statistics for the data are provided in Table 5.1.

Table 5.1: Descriptive statistics for the model variables

Variable	Obs	Mean	Std. Dev.	Min	Max
LNGDP	55	5.352	0.609	4.127	6.518
LNELEC	55	3.461	0.342	2.779	4.080

Source: Author, 2015.

The graphical expositions of the data indicate that the model variables are not stationary (Appendix 1). This was further confirmed by the Augmented Dickey-Fuller (ADF) and Phillips-Perron (P-P) tests which indicated that the data have unit roots but are stationary in first differences.

5.3 TESTING FOR STATIONARITY

The Augmented Dickey-Fuller Unit Root Test (ADFL) has been chosen to test whether the data sets are stationary or non-stationary. According to Stock and Watson (1989), time series data must be non-stationary, especially where Granger causality is to be tested to avoid a risk of analysing spurious results. According to Fuller and Cohen (1976), when data is found to be stationary, it is differenced to make it stationary.

In carrying out the stationarity tests, trend and intercept were considered in the series as shown in Table 4.13.

Table 5.2: Stationarity tests

Variable	Unit root test in levels		Unit root test in first differences		Order of Integration
	ADF	P-P	ADF	P-P	
LNGDP	-0.660	-0.762	-5.670***	-5.687***	I(1)
LNELEC	0.547	0.606	6.571***	-6.736 ***	I(1)

Source: Author, 2015

5.4 RESULTS AND DISCUSSION

5.4.1 Lag length criteria

In estimating the ARDL model, various lag length criteria that include the sequential modified LR test, Final Prediction Error (FPE), Akaike Information Criterion (AIC), and Hannan-Quin (HQ), and Schwartz Information Criterion (SC) indicated an optimal lag length of one (see Table 5.3 below). Therefore, 1 lag was applied in the estimation of the model.

Table 5.3: Lag length selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-88.93942	NA	0.130267	3.637577	3.714058	3.666701
1	49.48366	260.2354*	0.000602*	-1.739346*	-1.509904*	-1.651973*
2	53.30706	6.882117	0.000607	-1.732282	-1.349878	-1.586661
3	54.09013	1.346888	0.000692	-1.603605	-1.068239	-1.399735
4	55.49351	2.301543	0.000771	-1.499741	-0.811412	-1.237621
5	61.50119	9.371978	0.000716	-1.580048	-0.738758	-1.259680

Source: Author, 2015

5.4.2 Empirical results

The ARDL model for GDP growth and electricity consumption was estimated with an intercept and no trend. The bounds testing procedure indicates that there exists a valid long-run (or cointegrating relationship) between tax effort and its determinants. The computed F-statistic for the joint

significance of the long-run parameters is 4.21 (p=0.021) while the asymptotic critical upper bound values for the F-statistic at the 5 percent level of significance are 3.50 and 2.32. Since the computed F-values exceed the critical values at all conventional levels of significance, the existence of a stable long-run (level) relationship among the variables cannot be rejected. In other words, the variables are cointegrated. This implies that that there exists a stable casual long-run relationship between electricity consumption and GDP growth (Table 5.3). In addition, various diagnostic and CUSUM tests indicate that the model is well specified (Table 5.4) and stable (Appendices 2A and 2B).

Table 5.4: The ARDL model results

PANEL A: SHORT RUN COEFFICIENTS		
	Lag structure	
	0	1
D(LNGDP)		3.124 (2.02)**
D(LNELEC)	2.231 (1.72)*	1.392 (1.82)*
PANEL B: LONG RUN COEFFICIENTS		
LNGDP (-1)	1	
LNELEC (-1)	1.413 (3.130)***	
R-SQUARED	0.453	
F-STATISTIC	4.21	
Error correction	-0.081 (-1.97)*	

NOTES:

1) The coefficients are tabulated; t-statistics are in parentheses
2) *, **, and *** indicate significance at the 1, 5 and 10 percent levels respectively.
3) The upper and lower bound critical values of the F statistic at the usual 5% level of significance are 3.50 and 2.32

Source: Author, 2015

5.4.3 Analysis of short-run and long-run results

Analysis from the short-run results, reported in Panel A of Table 5.4, reveals that lagged GDP affects current GDP. This result points to inertia in the GDP generating process whereby current GDP levels are, in part, explained by previous GDP levels. In addition in the short run, electricity consumption is positively associated with GDP growth. There is a contemporaneous association between electricity consumption and GDP growth whereby current electricity consumption affects current GDP (lag 0). In addition electricity consumption affects GDP growth with a one year lag. In particular, an increase of current electricity consumption by 1 percent would result in a contemporaneous 2.23 percent increase in GDP. Similarly an increase of electricity consumption by 1 percent in the current period would result in a 1.392 percent increase in GDP in the following period. However, the short-run effect of electricity consumption on GDP is weak and only significant at the 10 percent level.

The long-run relationship between electricity consumption and GDP is shown in Panel B of Table 5.4. The effects of electricity consumption on GDP growth are large. The results in panel B show a positive and highly statistically significant effect of electricity consumption on GDP growth. The long run elasticity of GDP due to electricity consumption is 1.413, implying that for every 1 percent increase in electricity consumption GDP grows by 1.413 percentage points. These results are similar to the findings of Odhiambo (2009a), who showed that energy consumption spurs economic growth in Tanzania.

5.4.4 Results of cointegration and diagnostic tests

To test the null of no cointegration among the variables in the model, the F-test was used as explained in the previous section. The results of the F-test are reported in Table 5.4. The F-statistic is 4.21 and is greater than the upper bound critical value of 3.50 at the 5 percent level of significance, supporting the presence of cointegration.

Another efficient way of establishing cointegration is by examining the error correction term. Cointegration is inferred when the error correction term is negative, statistically significant and less than unity. In the model, the error correction tern is -0.081 and is statistically significant. This implies that 8 percent of the disequilibrium in the long-run relationship between GDP and electricity consumption is corrected each year. Although the speed of adjustment of 8 percent is rather low, the model nevertheless confirms the results of the F-test with presence of a significant and negatively signed lagged error term.

Other diagnostic tests, including the Breusch-Godfrey Serial Correlation LM statistic of 0.301 (0.583) and the Durbin Watson (2.031) tests for presence of serial correlation in the model, reveal presence of no serial correlation. Further, Ramsey's RESET test for functional specification confirms that the model is well specified (Table 5.5).

To test for the stability of the coefficients of the estimated variables, the CUSUM test, based on the cumulative sum of recursive residuals, and the CUSUMSQ test, based on the squared recursive residuals, were conducted. The graphical exposition of these two tests in Appendices 2(a) and 2(b) reveal that both the CUSUM and CUSUMSQ statistics stay within the 5 percent significance level and that they do not cross the critical value lines. It can thus be concluded that the model is stable.

Table 5.5: Model diagnostic tests

Diagnostic test	Computed test statistic	p-value
Durbin – Watson	2.031	N/A
Breusch-Godfrey LM test for autocorrelation	0.301	0.583
ARCH LM test	0.474	0.491
Ramsey RESET test	2.00	0.128
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	6.37	0.116

Source: Author, 2015

5.4.5 Granger causality

This electricity consumption economic growth nexus has been examined using the Granger causality test by different researchers including Ebohon (1996) on Nigeria and Tanzania, Belloumi (2009) on Tunisia, Aknilo (2008) on seven African countries and recently by Stern and Enflo (2013) on Sweden.

After discussing the results, the attention is now turned to Granger causality testing. This will help to understand the directions of causation among GDP and electricity consumption so as to arrive at solid conclusions and policy options. The principal question to be answered with Granger Causality testing is: Does electricity consumption spur economic growth or is it economic growth that spurs electricity consumption?

Table 5.6: Pairwise Granger non-causality tests

Null hypothesis	Chi-square	P-value	Conclusion
LNELEC does not Granger cause LNGDP	4.219	0.040	Reject
LNGDP does not Granger cause LNELEC	0.121	0.728	Accept

Source: Author, 2015.

Results in Table 5.6 indicate that there is a unidirectional relationship between electricity consumption and GDP, i.e electricity Granger causes GDP but GDP does not Granger cause electricity consumption. This finding is similar to that of Odhiambo (2009a) who showed that there

is a distinct unidirectional causal flow from electricity consumption to economic growth. These results highlight the importance of electricity consumption in economic growth.

5.4.6 Linking the theory to the results

Table 5.7 shows the linkage between the theory and the results of the study.

Table 5.7: Linkage between the theory and the results

Theoretical and Empirical Literature	**Findings from the study**
Relationship: Causal relationship between electricity consumption and economic growth.	There exists a unidirectional causal relationship between electricity consumption and economic growth in Uganda.
Consumption depends on current disposable incomes	Consumption depends on current incomes, previous incomes and previous consumption.
Consumption does not depend on the previous two year incomes	

Source: Author, 2015.

5.5 CONCLUSION

The chapter has presented the results of the analysis on the existence of a relationship between electricity consumption and economic growth in Uganda. The data used was in respect to electricity consumed in the country between 1960 and 2014, including imports from neighbouring countries.

The results have shown that there exists a strong correlation between the theories and the findings of the study using the data analysed.

C H A P T E R 6
C O N C L U S I O N

6.1 INTRODUCTION

This chapter discusses the results of the previous five chapters of the study and summarises the presentations made in the previous chapters. It also analyses the implication of the results and suggests future areas for research. This chapter also presents limitations of the study while providing possible mitigation measures.

6.2 SUMMARY OF FINDINGS

The objective of the study was to examine the relationship between electricity consumption and economic growth in Uganda. Specific objectives of the study were:

i) To estimate the short- and long-run relationships between electricity consumption and economic growth in Uganda; and

ii) To examine the direction of the causal relationship.

These objectives were addressed using empirical analysis of secondary data on electricity consumption and economic growth. Electricity consumption data was obtained from Electricity Regulatory Authority (ERA) database and the public library. This data is publicly available on line and in the ERA resource centre.

To examine the existence of a causal relationship between electricity consumption and economic growth, the data and equation were estimated using econometric regressions. Electricity consumption was the dependent variable while electricity consumption was an explanatory variable. The following were the major findings of the study were:

There is a positive relationship between current year's income and the previous year's consumption of electricity, and the statistical significance is high at 0 percent.

Previous income is strongly related to the current consumption with a statistical significance of 0 percent. However, the significance is negatively correlated. Consumption of the previous two years is not significantly related to current income.

6.3 CONCLUSION AND RECOMMENDATION

The study has identified that consumption of electricity is significantly related to economic growth. However, there no feedback hypothesis/bi-directionally relationship between the two variables studied. Given that electrification access and rate is low in Uganda, efforts should be directed towards increasing accessibility to the grid and providing incentives to the rural population to consume electricity.

Furthermore, government policies should be aimed at increasing generation of electricity and exploring alternative sources of electricity to increase electricity generation in Uganda. Energy conservation measures aimed at suppressing demand will in the long run hurt the economy.

6.4 LIMITATIONS OF THE STUDY

The major limitation of the study is the lack of sectoral level data that would have allowed for a more in-depth analysis of the relationship between sectoral value added and electricity consumption. In addition price data was not available. This would have been useful in estimating the effect of prices on sectoral value added and electricity consumption. However, these limitations were overcome by using the aggregate data for electricity consumption and total national value added (GDP).

6.5 AREAS OF FURTHER RESEARCH

Given the limitations of the current study, future research should try to estimate the relationship between electricity consumption and sectoral value added. The same can be done for residential electricity consumption. The analysis at the lower disaggregated levels can provide more nuanced insights into the relationships between electricity consumption and economic growth.

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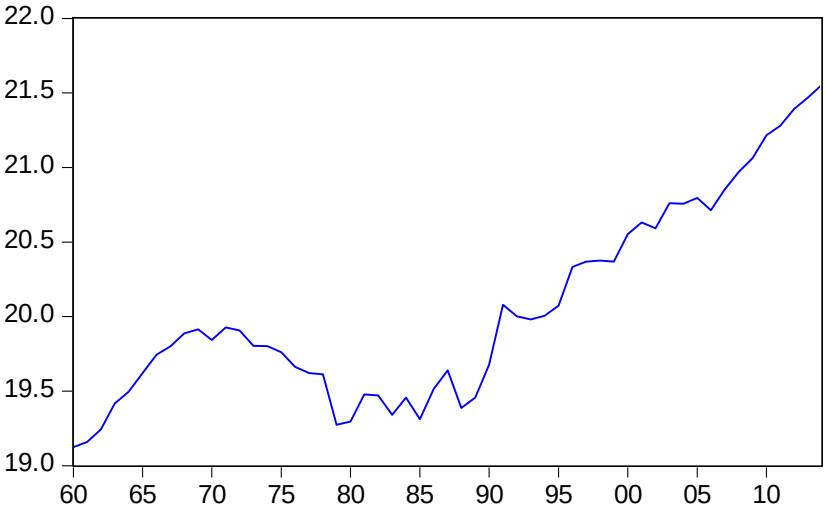
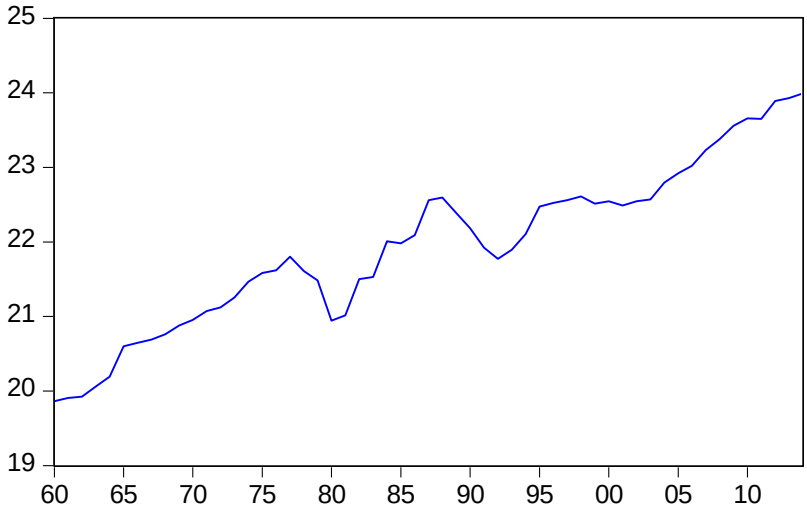
A P P E N D I C E S

APPENDIX 1: GRAPHICAL EXPOSITION OF THE DATA

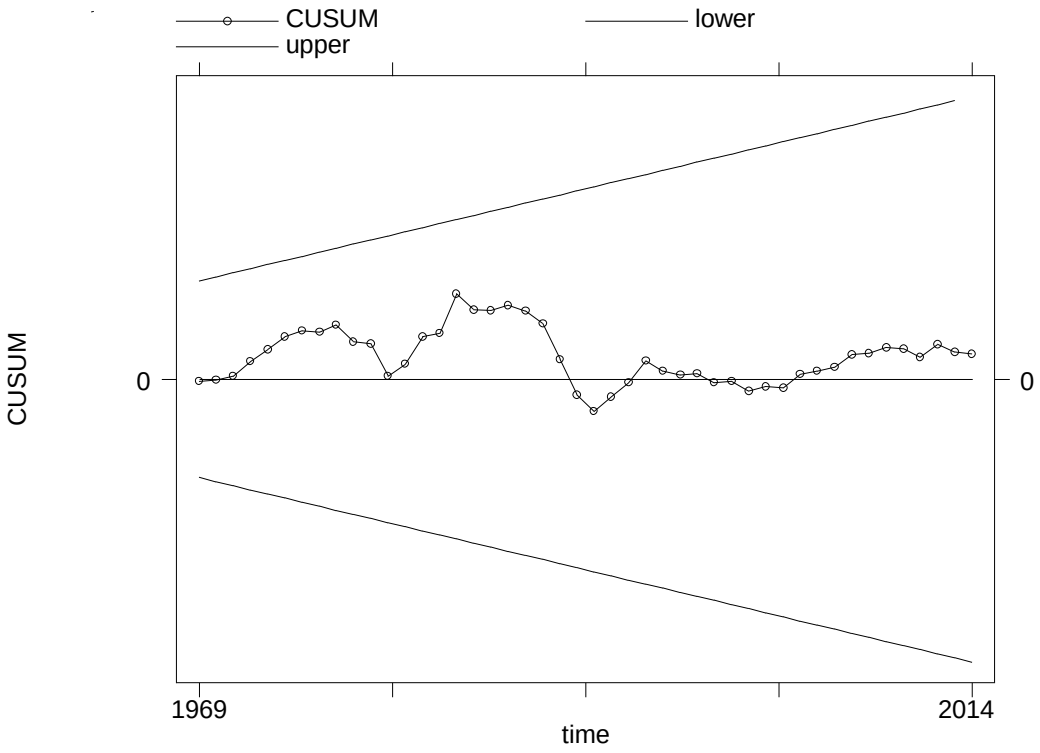
LELEC



LGDP



APPENDIX 2A: CUSUM RESIDUAL PLOTS



APPENDIX 2B: CUSUM SQUARED RESIDUAL PLOTS