THE RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN KENYA: 1970-2004 ,

BENSON joKWIRI

A Research Project submitted to the School of Economics in partial fulfillment of the requirements for the award of Masters of Arts in Economic Policy and Management of the University of Nairobi

July 2006

DECLARATION

[his research paper is my original work and has not been submitted or evaluated lor a degree programme in any other university.

Signature.... Date... p . / o Q .

BENSON OKWIRI

This research paper has been submitted for examination with our approval as university supervisors.

Signature . . . . ff.1H-.... . . . . Date...£V.../. 7.1.C?.<

DR. NEI.SON 11. W. WAWIRL

UNIVERSITY OF NAIROBI
I^TiFR.CAMACOUECr.ON

Signature c d f c L. . . . . ^ . . . . ^ 1 1 1 ^ . . " . . ^ .

DR. TAB1111A KIRITI-NCi'ANG'A

DEDICATION

To my parents for helping mc pursue the path of hard work in academics which has seen me this far.

TABLE OF CONTENTS

1,1ST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude lo iny supervisors Dr. N. Wawire and Dr. **T.** JCinti-Ng'ang'a who assisted me greatly and offered a lot of guidance and support while conducting this research project.

I would also like to say a big thank you to Martin Odhiambo for assisting me with the usage and interpretations of results from E-views manipulations and my former classmates in the July 2004 M.A (Economics) intake, especially Francis Anyona. Donald Otieno and Charles Gatei for their unparalleled encouragement.

God Bless.

ABSTRACT

This study set out to evaluate the probable relationship between electricity consumption and economic growth in Kenya and to determine whether there is either short run or long run equilibrium relationship between these two variables. To achieve the above objectives both granger causality analysis and Error Correction Modelling (ECM) were applied to the data scries for electricity consumption and economic growth. The time series data for both annual electricity consumption and GDP was obtained from government publications for the period I<>70-2004.

Prior to testing for causality, analysis of stanonarity for both variables revealed that the raw data sets were non-stationary and only when differenced and subjected to the same tests became stationary. Further diagnostic tests for regression residuals including residual and stability tests established that both electricity consumption and economic growth data series exhibit normal distribution pattern. The series also did not show any serial correlation neither did they show aulorvgrcssivc conditional heteroscedasticity effects nor white noise and had very stable regressions. Therefore, the subsequent regressions conform lo the OLS assumption of consistency and efficiency.

Estimation results from the granger causality analysis indicated that there is a bidirectional relationship running from electricity consumption lo real GDP and vicc versa. Thus an increase in electricity consumption would raise real GDP while improved economic growth would trigger higher electricity consumption.

DEHNI I ION OF OPERATIONAL TERMS

Economic growth: refers to an increase in the volume of goods and sen'ices produced by an economy. It is generally a factor of an increase in the income of a nation and is conventionally measured as the percent rate of increase in nominal gross domestic product or real

GDP-Gross Domestic Product (GDP): The total market value of all final goods and services produced within the political boundaries of an economy during a given period of time, usually one year.

Real GDP: This is inflation-adjusted measure of GDP that reflects the value of all goods and services produced in a given year, expressed in base-year prices.

Electricity: is the energy dissipated in an electrical or electronic circuit or device per unit of time.

Stationarity: is a quality of a data series in which the statistical parameters, which include mean and standard deviation, do not change with time. The analysis of time scries data sets is not complete unless stationary data is used and if the non-Stationary , ' m c series data is used, it may lead to conclusion whose validity is questionable.

Granger Causality: is a technique for determining whether one time series is useful in forecasting another. Ordinarily, regressions reflect "mere" correlations. A time series A' is said to Grangcr-causc *Y* if it can be shown, usually through a series of I'-tests on lagged values of .V (and with lagged values of >'also known), that those .V values provide statistically significant information on future values of >'.

Error Correction-. An error-correction model is a dynamic model in which "the movement of the variables in any periods is related to the previous period's gap from long-run equilibrium. Error Correction Model (ECM) can lead to a better understanding of the nature of any nonstationarity among the different component series and can also improve longer term forecasting over an unconstrained model.

F statistics test: The F test for linear regression tests whether the slope is significantly different from 0. which is equivalent to testing whether the fit using non-zero slope is significantly better than the null model with 0 slope.

CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1 Importance of electricity

Electricity plays an important role in economic growth lor the modern socicty given that it can meet a diversity of human energy needs compared to other forms of energy. The modern infrastructure, which include expanded road network, belter urban transport, improved access to water and sewerage services and increased availability, reliability and affordability of modem energy, is a critical pillar of economic recovery' programmes in Kenya (Republic of Kenya. 2003, 2004 and 2005). Accclcratcd economic growth and rising productivity of all sectors are among the overall objectives of the government (Republic of Kenya. 2004). Ihe extent to which they arc realized depends on availability of crucial factors of production such as quality commercial energy. Studies such as UNDP (1997), Goldemberg *el al.* (2000) and WEC/FAO (1999). have shown that the level and intensity of commercial energy use tn a country is a key indicator of economic growth and development. Those with low per capita consumption of commercial energy register correspondingly low per capita GPP.

The relationship between economic growth and clcctricity consumption, aggregated as well as disaggregated into customer categories, is an important subject of analysis and debate. It has attracted considerable interest among economists and policy makers especially those dealing with modern/commercial energy issues (AI RLPRliN. 2004).

The reason hehiixl this is the fact that economic growth of a country that is propelled by modem efficient energy contributes to more opportunities and bener welfare among the people. Thus economic growth continues to be one of the major goals set by governments worldwide

According to Ku/ncts as cited in Jhigan (2004 pp 28), "economic growth is .1 long time rise 1l1 a country's capacity to supply increasingly diverse economic goods to its population." The growing capacitv is powered by modern commercial energy, and electricity ranks above the rest (I NDI\ IW7). Among the factors that determine economic growth in Kenya, electricity consumption is of particular interest, and forms the basis of policy direction and planning (Kam for. 2002).

It is notable that a substantial volume of empirical research, such as Asalu-Adjaye (2000) and Shiu .•/ <// (2004) in the Asian continent has been directed towards identifying the elements of electricity consumption tluit bear significant association with economic growth. These include usage by industries, rural productive sectors and small scale informal enterprises, which employ substantial proportion of the population.

Electricity is considered one of the most modem and versatile energy locally produced and attractive for varied purposes because of its efficiency (WliCVTAO. 2000: UNDI\ 2000). It is a convenient fuel that ranks highest on the energy ladder and its importance as a critical input for economic growth is well established (Masih, |<W6; UNDP, 2000). Studies by Al KLPRliN *ct at,* (200-1). UNDP (1097) and IEA (2000) have shown that electrification should he pan and

pared of am economic growth strategy, if development has to mean quantitative and qualitative improvement in people's lives. The choices and opportunities available to iinliuduals can be dramatically widened by access to electricity (Jumbe. 2004).

I he World Fnerg) Council (2001) estimates that nearly two billion people in the developing world do not have access to electricity lor productive uses, lighting and cooking. And yet the level and intensity of electric energy use in a country is a key indicator of economic growth and development (Jumbe. 2004).

1.1.2 Performance of Kenyan economy

I he economy of Kenya lu»s had various levels of performance in the last four decades since independence. I our phases are clearly identifiable: a rapid growth phase over 1963-73; an era of external shocks over I *>74-7*> dominated by oil price shocks and a eolfee boom: a period of stabilization and structural adjustment in the 1980s. and an era of liberalization and declining donor inllows from 1990 to date. There was a strong macrocconomic performance in the early 1970s, which was never replicated in the later periods (\1wega and Ndung'u, 2002). I he macrocconomic performance of the economy since independence is best understood in the context of tl>e external shocks and internal challenges that the economy has had to adjust to (Republic of Kenya. 2002).

Kenya's economy grew at impressive rates in the first decade after independence, with GDI' expanding by 0.6 percent per annum. This was attributed to increased agricultural output, rising domestic demand, expansion of the regional market, and expansion of the manufacturing sector and substantial inflows of foreign aid

The performance of markets in the 1970s was driven by the public scctor. which was the major investor and employer. However, exogenous factors compounded by inadequate macroeconomic policy response reversed the impressive economic growth of the first decade I he tirst oil crisis of 1973 impacted negatively on the rapid growth rate, decelerating the rate to below 4 percent lor much of il»e 1970s except for 1976/77 when the coffee boom led to the rising GDP growth rate from 5.5 percent in 1967 to 8.2 percent in 1977 (Republic of Kenya, 2002).

I'hc collapse of l ast African Community (P.AC) in 1977 coupled with the second oil crisis in 1979 further decelerated the economic performance. The decade witnessed some policy backlash in the form of controls, which at first worked to control balance of payments and inflationary pressures, but later created distortions in the economy and thus checked production expansion of both firms and smallholder farms aikl overall economic growth (Mwega and Ndung'u, 2002). The system ol controls prevented and chcckcd the growth of product markets, financial markets and created room for rent seeking

Economic performance worsened in the 1980s and 1990s. Since J9X0s. high and sustainable growth proved elusive since the overall trend of real GDP growth consistently declined In early 1980s, the Kenyan economy experienced drought world recession and internal debt crisis, which worsened the domestic economic situation. In addition, misaligned real exchange rates, tin- fixed interest rate regime as well as poor commodity pricing undermined macroeconomic stability.

The system of controls continued into the 1980s and was gradually eliminated in tin: early **1990s.** Implementation of reforms such as liberalization and deregulation of trade and exchange rate regimes, public and financial sector reforms by the government to address the macroeconomic instability led to resurgence of growth, which averaged 5 percent over 19X6-1990.

In the 1990s. GDP growth was very erratic. The poor economic performance was mainly due lo the declining donor support; poor weather and infrastructure; insecurity; depressed investment; declining tourism activities and poor performance of manufacturing sector In addition. Mwcga and Ndung'u (2002) noted that the protracted recession in the 1990s to the current period was due to slow process of structural adjustment within key sectors, the emergence of policy reversals and the reluctance in the liberalization process that badly affected the development of markets.

Overall GDP growth declined further to 2.5 percent between 1990 and 1995 and to 2 percent between 1996 and 2000 (Republic of Kenya. 2001). On the basis of the 1993 Sy stem of National Accounts (SNA), the Kenyan economy expanded by a real GDP of 4.3 percent in 2004 (Central Bank Kenya. 2005) compared with the adjusted growth of 2.8 percent in 2003.

The Central Bureau of Statistics (CBS), in 2004, adopted a new methodology (1993 SNA) of computing national accounts, whereby GDP at constant prices is measured at market prices rather than factor cost as was done in 1968 SNA. which provided figures for up to 2003. I he new series has real GDP measured at 2001 market prices and gives figures from 2000.

From Table I.I in ihe Appendix, some key sectors show some disparities in terms of sector performance since 2000. Agriculture, manufacturing, hotels and restaurants, and financial intermediation have been declining while on the other hand transport and communication, real estate renting and business services, education, health and social work liavc. over tlx: same period, increased their sectoral contributions. The share of manufacturing declined from 10.3 percent in 2000 to *9.*)* percent in 2004 while that of agriculture declined from 29.1 percent to 24.2 percent. I ransport and communication recorded increased contribution over the same period from 8.') percent to 10.3 percent and that of the education sector increased from 5.9 percent in 2000 to 7.8 percent in 2004.

1.1.3 F.lcctricity generation structure and economic growth

Most of the electricity used in Kenya lias been generated from hydroelectric sources and supplied exclusively by Kenya Power and Lighting Company (KPLC) since 1963. But after ihe liberalization of the sector, which commenced with the enactment of the *Electricity Power Act of 1997.* the generation structure changcd. With the split of KPLC into three new entities: Kenya Electricity Generating Company. KENGEN (for electricity generation). KPLC (for transmission and distribution) and Electricity Regulatory Hoard. LRU (regulatory functions), roles and assets were divided accordingly. The present arrangement effectively opened up the sector to generation of electricity by Independent Power Producers (IPP).

The generation structure of the electricity power sector as at April 2003 shows that the country had a combined installed capacity of 1.162 MW of which 1.051 MW is considered effective (KPLC. 2004).

The total capacity is confined to the interconnected system while the isolated system comprised of the seven diesel stations and a single wind turbine. Apart from the electricity available from the interconnected grids and the isolated grids in the country , there are three major projects expected to add 160 MW of power within four years from 2004. Public sector institutions that generate electricity account for 8.1 percent of the effective capacity with the rest coming from the four private sector generators.

The commercial energy sector in Kenya is dominated by petroleum and electricity as the prime movers of the modern sector of the economy, while woodfuel provides energy of the traditional sector including rural communities and the urban poor. Commercial energy consumption has for the last three decades experienced a declii>e. due to weak and sluggish economic performance and is further limited by the fact that about 15% of the population has access to electric power.

As at July 2005, KPI.C had electricity supply contract with about 720.000 customers 80.000 who fall under Rural Electrification Programme. This is in stark contrast with tin; growth in commercial energy consumption in countries, which have witnessed good economic performance such as Egypt and South Africa both of which arc Kenya's trading partners. These two countries registered high growths in both energy consumption and ("iross National Income (Al REPRKN. 2004).

1 here arc contrasts in the level of economic growth attained vis-a-vis electricity consumption between Kenya and other East Asian countries. South East Asian countries such as Malaysia. South Korea and Singapore registered the fastest increment in both per capita incomes and

commercial energy consumption of energy, which could be a reflection of their booming economies (Table A5 in tl»e Appendix II)

Kenya's low and declining commercial energy consumption over the lost three decades could be associated with a corresponding falling trend in economic performance. From fable A4 in appendix II it is noted that countries such as Egypt. Malaysia and Singapore, which used commercial energy (largely electric energy) at annual rates of over 4 percent witnessed a corresponding higher annual economic growth of over 7 percent. This implies that higher economic growth rates are attainable through ihc increased use Of commercial energy

1.2 Statement of the problem

The level and intensity of commercial energy use are often regarded as key indicators of economic growth and development in a country (Republic of Kenya. 2003). It is well acknowledged that the power sector plays an important role in the economic activity of developing countries by powering major productive sectors (Ng'ang'a. 1990: Onjala. 1992: World Bank. 2000; Goldemberg el al. 2000: Kamfor, 2002: Kareke/i. 2004; II A-Kenya. 2005. Acccss to electricity by all sectors is therefore crucial, particularly to manufacturing and services, holding other factors constant.

From the background section, the amount of electricity consumed in Kenya does not correspond with the level ol economic growth that has been witnessed over time as evidenced from studies done by Kamfor (2002). Republic of Kenya (2002. and 2004). Despite Un-remarkable growth in the clectric power industry since independence, the speed lias not kepi pace with economic growth. The rate of growth of electricity consumption does not show a direct correlation with ihc growth in GDP (AFREPREN. 2005). Thus, there is no clear understanding of the relationship between electricity consumption and economic growth. The desire was to investigate the nature of relationship between electricity consumption and economic growth using Kenyan data.

The study addressed the following research questions:

i. Is there existence of causality between the electricity consumption and economic growth in Kenya?
ii. What model shows the specific nature of the relationship?
iii. Is there a short run or a long run equilibrium relationship between electricity consumption and economic growth?
iv. What policy implications can be drawn from die study?

1.3 Objectives of (he study

The general objective of the study was to investigate the relationship between electricity consumption and economic grow th in Kenya for the period 1970-2004.

I he specific objectives of the study therefore were:

i To test electricity consumption and economic growth relationship for causality
ii. To model the relationship in order to show its specific nature.
iii. To establish whether there is a short run or long run relationship between electricity consumption and economic growth.
iv. | o draw policy implications based on ihc findings.

1.4 Justification of llu-study

Givcn the role plavcd by clcctricity in economic growth (Ngunga, I WO) and the growing interest in the study of relationships between the variables (Shiu «•/ <// (2004), an investigation of the said link became important to shed light on what informs energy policy in Kenya.

The study findings were aimed at achieving a better understanding of the role of electricity in the Kenyan economy. An understanding of the prevailing relationship between electricity use and economic growth will facilitate sound electricity sector planning. It also shed light on future electricity policies regarding both grid and olf-grid power extensions and nationwide interconnections to be undertaken by various implementing agencies, including KPLC. Hopefully, this would go along way to reorient the direction of policy focus on electricity generation, transmission, distribution and consumption patterns to reach as many productive firms/industries as possible

This research sought to fill the gap in tlie empirical literature on the model of the relationship between the electricity eonsumption and economic growth, besides adding value to academic knowledge 011 clecirilieation-cconomy nexus in Kenya.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chaptcr provides a review of literature on electrification and economic growth especially studies that have attempted to explain the specific relationship between the variables. It also attempts to relate this study to available literature. It starts with the theoretical literature then empirical literature followed by an overview of available literature.

2.2 Theoretical literature

Energy is considered a pervasive commodity with an indirect demand (Anaman. 2000). Its use facilitates all human endeavor, as well as social and economic progress. As such it contributes to widening of opportunities and empowerment of people to exercise choices. Conversely, its absence can constrain people from contributing to economic growth and overall development Many countries have therefore considered production and consumption of sufficient modem energy to be one of their main development challenges.

Consequently, studies have shown that the magnitude of energy consumed per capita has become one of the indicators of 'modernization' and progress of a country (Amman. 1969; UNDP, 1997; Anaman. 2000). Although, there is a rising criticism of the naive view that a nse in energy consumption automatically indicates economic development, there is empirical evidence that modern energy supply can revolutionize economic and social life, notably among the rural poor (Ng'ang'a, 1990; Onjala, 1992; Anaman. 2000).

According lo Goldembcrg *et al* (2000), energy is central to achieving the interrelated economic, social, and environmental aims of sustainable human development. But if Kenya has. to realise this important goal, the kinds of energy produced aikl the ways they are used will have to changc from the current status. I lie author asserts that the energy needs of the two billion people worldwide who have no means of escaping continuing cycles of poverty und deprivation cannot simply be ignored. Oilier cliallenges confronting them include; the high prices of energy supplies in many countries, the vulnerability to interruptions in supply and the need for more energy services to support continued development

F.fforts made by nations worldwide in providing electricity services contribute towards one of the Millennium Development Goals (MDGs), as set out in one of the declarations of World Summit on Sustainable Development (WSSD) that seek to halve extreme poverty by the year 2015. I his serv ice addresses energy poverty, w hich is a component of general poveny and is essential lor the achievement of all other MDG$(UNF.P. 2<HM). I rtergy poverty goes hand-in-hund with general poverty as proven by ilk- fact that areas which lack electricity also have low Human Development index. IIDI (GNLSD, 2004). HD! is an index developed by UNDP as a component of longevity, knowledge and standard of living.

Modern energy provision is a key factor in economic and social development and more emphasis needs to be placed on the needs of the productive sectors propelled by electric power. Rural areas in Suh-Sahnran Africa still derive most of their energy from biomass sources (AFRFPRFN, 2004). But lack of modem energy services in rural areas constrains efforts to diversify their economy and improv e living standards (Republic of Kenya. 2004).

Despite the rapid urban growth experienced in Sub-Saharan Africa (SSA) over the last 20 wars and the fact that the population distribution is likely to change in the near future, it is estimated that 68 per cent live in rural areas with irregular income flows (World Hank. 2000). I he high levels of poverty arc reflected in the consumption pattern of modern energy such as kerosene, LPG and electricity. Per capita consumption of modern energy in such countries is very low when compared to other regions. Between 1990 ami 1997. per capita consumption ol electricity in SSA. excluding South Africa, has remained small and stagnant dropping from 44 7 to 126 Kwh (Karekezi <•/ ,;/. 2001)

2.3 Empirical literature

Although economic theories do not explicitly state a relationship between energy consumption and economic growth, there has been a heightened interest to undertake related empirical investigations for the recent two decades. I he study of the causal relationship between energy consumption and economic growth started with the seminal work of Kraft and Krafl (1978). in which the standard granger causality test*, was applied on time series data ami causality was found to run from GNP to energy consumption in the United States. The granger causality formula is as follows;

Y I - E O H + Y M ________________________________ 2.1

The information added to predict Y, is contained in the lagged values of X. and the error term. Therefore, testing for significance of the coefficients was done using the F-statistics whereby if aji is identically zero, then Y. is predicted solely from its own past values ami the stochastic term. Granger causality can also be tested in the reverse direction by specifying the equation below;

X r I P i . + X«.. +I P ii Y.+e, 2:

If the null hypothesis that fa 0 is rejected, then Y, granger causes X«. The scries of F-suitistics after regressing equations 2.1 and 2.2 may give the following oucomes;

- One \ ariahle granger causes the other
- Both variables granger cause each other thus we have presence of feedback between them
- The variables do not cause each other hence there is no granger causality. The response of feedback between X and Y implies that a shock on any of these variables will peter out rapidly but will have permai>enl effects.

Ai the aggregated level, electricity consumption, which is an indicator of socioeconomic development, has been of interest. Ferguson *ci ai* <2000) analyzed the correlation between clcclricits use and economic development in over 100 countries. They found tliai for the global economy as a whole, there is a strong correlation between electricity use and wealth creation.

Since correlation analysis docs not involve causality, recent studies such as Ghosh (2002); Shiu and Lam (2004); Moritomo and Mope (2004); Jumbe (2004); Wolde-Rufael (2004); Narayan and Smyth (2005) and Yoo (2005), have focused on the relationship between electricity consumption and economic growth for several developing countries. Empirical studies were later extended to cover other industrial countries like the I nilcd Kingdom. Germany. Italy. Canada. France, and Japan (Yu and (hoi. 1985: Erol and Yu. 1987).

In subsequent studies, instead of relying on the standard granger causality test given above, the cointegration and error-correction models (ECM) were applied to test for stationarity of ihc variables in the lime-series. I he ECM used is specified as follows

AVI^s •VI«*iG>^Ay>i •EMOA*.,•e_M 2.3

A*t= ci,.u*//,.|>^U||(i)Ay,.| *£u_u(i)Aj^|+Cn 2.4

Where Y, and X< represent natural logarithms of real GDP and electricity consumption, respectively, and (AY,. AX,) are the dilTcrences in these variables that capture their shorl-run disturbances, cy,. r.x, an; the serially uncorrected error terms, and m«.i is the error correction term (ECT), which is derived from the long run cointegration relationship - i.e. Y. Hn+fJiXi+m, and measures the magnitude of the past disequilibrium (it is called the F.CT since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments).

Moreover, some studies Ibr example Stern (1993 and 2000), tested for granger causality in a multivariate setting by using a vector auto regression model (VAR). In the recent past, empirical work on the causal relationship between energy consumption and economic growth has been focused on Asian economies. Glasure and l.cc (1997) for example, have examined ihc causal relationship between energy consumption and GDP for South Korea and Singapore using the error correction model (ECM). The results of the cointegration and error-correction models indicated bi-directional causality for both countries. In contrast. Granger causality tests SIK>W a unidirectional relationship running from energy to GDP for Singapore, but no causal relationship between energy and GDP for South Korea. Ihc results for South Korea contrast with those of the Yu and Choi (1985) study, which showed unidirectional causality from GNP to energy consumption, based on the standard Granger tests on time series data.

The results of studies for Taiwan, another newly industrialized economy, arc also mixed. Cheng and Lai (1997) using Hsiao Granger tests find causality running from GDP to energy consumption without feedback, while Yang (2000) using Rl'M found a bi-directional causality. Yang's result is consistent with the findings of an earlier study done bv Hwang and Gum (1992). I he author attributes the difference between results found in the study and that of Cheng and l.ai to the use of different sample periods, and the choice of different price indices in measuring real GDP. Masih and Masih (1998) have applied Johanscn's multiple reintegration tests for the cointegration of the energy consumption, real income, and price levels of two less-developed Asian countries: Thailand and Sri Lanka, rhey found that energy consumption was itself relatively exogenous, and concluded that it played an important role in influencing income and prices.

Asafu-Adjaye (2000) used cointegration and error-correction modeling techniques on time series data to estimate the causal relationships for India. Indonesia, the Philippines, and I hailand. I he LCM applied is similar to the one described above. Asafb's results indicated a short run unidirectional Granger causality running from energy to GDP for India and Indonesia, but a bi-directional relationship for the other two countries. Asafu's empirical results for Indonesia and the Philippines are different from other studies (Yu and Choi. 1985; Masih and Masih. 1')%), Moreover, Asafu included energy prices in the study, and found that energy, income and prices were mutually causal for the Philippines and Thailand. For India and Indonesia, however, the causality is unidirectional, running from energy and energy prices to income.

The results for India in Asafu-Adjaye's study contrasts with those obtained from Ghosh (2002). (ihosh has applied (iranger causality test on the bivariate vcctor autoregressive model (VAK) to test for causal relationship for India. Similar to this research study. Ghosh focused on a particular form of energy, i.e. electricity. The results indicated that there was unidirectional Granger causality running from economic growth to electricity consumption without any feedback effect.

fable A3 in the appendix, provides a general summary of the empirical findings of the relationship tests between energy/electricity and economic growth using mainly F.C'M and standard granger causality modeling for a number of Asian economics. It also shows studies with similar results that applied same or different formula and those with different relationship results.

Whereas the development of empirical literature on the impact of electrification on the economy in developing countries especially SSA has been an ongoing exercise, such studies in the Kenyan context are hampered by lack of data. A number of studies have been conducted in the country's energy sector particularly in tlie 1980s. Most of them were however initiated as consultative surveys for foreign donors and international organizations (Ng'ang'a, 1990; Onjala. 1992). I hey therefore lack academic orientation. More scientific research started in the late 1980s.

Leigh *el ol* (1979) used cross sectional data to conduct analysis of the relationship between commercial energy production and consumption and economic and social development in one hundred and twelve LDCs including Kenya. I heir analysis indicated strongly that energy is an important contributor to economic and social development in LDCs and that per capita commercial energy consumption is positively and significantly related to tlie industrial portion, but not agricultural portion, of GNP per capita

Scnga. House and Manundu (1980) undertook a study on trends in energy consumption in Kenya using time series data to generate price and income elasticities of demand for energy and its components. Their estimation was a two-variable static equation expressing energy demand as a function of prices and output for the three commercial energy forms (coal, electricity and petroleum products). This concurs w ith demand economic theory for a normal good which reacts to changes in prices and incomes. A number of empirical studies such as Ng'ang'a (1990) reveal that there are many factors which affect energy demand that were not considered by the three scholars and thus the two-variable generalization was not comprehensive.

Mureithi. Kimuyu and Ikiara (1982) conducted a study to analyse the impact of increased energy costs on balance of payment, cltoicc of production technology and real incomes in the country using time series data. I his study revealed the existence ol possibility of substitution between different fuels and between energy and capital, and hcncc energy was not a major contributor of economic problems (for example inflation) that the country experienced.

World Bank and I NDP (1[l]>82) addressed themselves to issues of energy supply and demand, interfuel substitution and demand management, energy prices and taxes, and energy investment and technical assistance. I he two findings were that the cost of imported energy was becoming a major burden and the state of deforestation in the country worsened. They predicted a major change in relationship between GUP growth and tl>e growth of petroleum products and electricity.

Beijcr Institute (19X4) did studies, which were mainly descriptive, to investigate the opportunities and constraints for energy and development in the country. I heir focus was to clarify the problems attendant upon tin: accelerated depiction ol the indigenous wood resources and assessing range of policy initiatives to address those problems. Ihe studies concluded that an integrated energy plan needed to he developed to encompass demand and supply management and for the alternative sources of energy to reduce heavy reliance on wood fuel.

Jama (1987) conducted a study in Kiambu district to determine how energy cost and policies affect energy consumption, the level of living and economic activity in rural areas I he study was a micro-level survey of energy-economy interaction. I lie main finding was that Kenya faces a long-term problem for both commercial and non-commercial energy because of the inability to expand commercial energy imports ihui is constrained by export earnings.

Kiniuyu (1988) investigated relationships that constitute demand for commercial energy in the country and the work was confined to identifying the principal determinants of demand for specific fuels, l hree multiplicative equations to estimate the demand models for fuels were adopted. The study revealed that the determinants were aggregate production, price of energy using equipment, price of energy and structure of the economy

Kamfor Consultants (Kamfor. 2002) undertook a national survey on energy demand, supply and policy strategies in the country and tound that traditional fuels still dominate rural energy consumption even though they contended that rural areas due to unmet demand hold a lot of promise in turning around the country's economic recovery. Among their recommendations is the need to modernize energy services, diversify energy choices, promote rural energy markets and expand rural electrification.

AI KRPREN (1W2) undertook the regional impact assessment of electrification in Zambia, Ethiopia, Botswana and Lesotho using both ex-post analysis through surveys and ex-ante appraisal using financial and economic analysis. They reveal that rural electrification has been undermined by financial cost factors, long transmission distances, high transmission costs and low load factors in rural areas, factors tliat create a slurp imbalance between rural and urban areas. The} noted that electrification is economically feasible; having resulted in increased agricultural production, supply of drinking water, evening school programmes, better lighting, expanded agricultural markets, increased number of tourists and income generation. They recommended intensiv e electrification and a combination of smart subsidies targeting tlie poor and higher tarilTs to generate funds.

2.4 Overview of literature review

1 \en though there is not much theorcticul and empirical evidence surrounding the association between electricity consumption and economic growth, especially for developing countries in SSA. the subject has remained controversial to this day. The existing works provide no clear consensus on the relation between the two variables. As aforementioned, prior empirical studies vary in terms of data sets used, econometric techniques employed, and often produce mixed results.

A majority of recent studies indicate a bidirectional relationship between energy use and economic growth. It is also noteworthy that the development of mctliodology for studying the relationship between the two variables has mostly followed the development of time series techniques. However, most studies on long-run relationships and lead lag relationships between energy consumption and economic growth have been carried out in the two step Lnglc and Granger approach.

It is evident that many of the empirical studies on the relationship between electricity consumption and economic growth have been conducted using cross-country data in attempts to explain the observed differences in economic growth rates across countries. Such studies have been useful in identifying uniformities across countries and overtime and have helped to detect important associations between the two variables. However, cross-country growth regressions do not capture the dy namics of the relationship and disregard country-specific factors (Shiu *et a/,* 2004; Yoo, 2005).

Accordingly, a study of time scries analysis for an individual country may he a more insightful process than averaging data in a cross-country analysis. To this end. the focus ol this study lies in the empirical investigations of tlie relationship between electricity consumption and economic growth.

CHAPTER THREE

THEORETICAL ERAMEWORK AND METHODOLOGY

3.1 Introduction

This chapter provides the theoretical and methodological framework used to analyse the data and provide direction in terms of attempting to meet the set objectives. It gives an outline of the empirical models used and various tests performed to ascertain the validity of data and robustness of the models including; stationarity. cointcgration. correlation analysis and diagnostic tests.

3.2 Theoretical framework

Even though economic theory offers very little guidance as to the appropriate functional form for the regression under investigations, this study draws theory' from the derived demand function (Onjala. 1992). The relationship between electricity consumption and economic growth is viewed in this study intcrms of derived demand for factors of production. Economic growth requires a capital factor like electric energy to propel its grow th and consequently to trigger further need for more electric power.

Factor demand represents the willingness and ability of productive activities to hire or employ factors of production. Il relates factor price and factor quantity, specifically; it is the range of factor quantities that arc demanded at a range of factor prices. This is one half of the factor market. The other half is factor supply. The factors of production arc subject to factor demand that represents the demand side of the factor market, capturing the relation between the factor pricc and the quantity demanded.

Factor demand is a derived demand meaning that the demand tor an input is derived from, or depends on. the demand for the output In this study electricity consumption could be the factor demanded to achieve the goal of enhanced economic growth and vice versa. If the output is more highly demanded, then the input used in production is also more highly demanded. If the output commands a high price, then the input used in production also commands a high price. The notion tluit (IK* demand for a factor of production, or an input used in the production of a good, depends on the demand for tlwr output being produced. I his concept highlights the two key aspects of factor demand One is that factor demand depends on the value of the good being produced. Inputs that produce more valuable outputs arc themselves more highly valued. I wo is that factor demand depends on the productiv ity of the input. Inputs that produce more output arc themselves more highly valued.

t herefore, this brings to focus the idea of the nature ol relationship between electricity consumption and economic growth in Kenya.

3.3 Empirical model

3.3.1 Granger Causality

The definition of granger causality used to assess the first objective conforms to the conventional understanding of the term, but otters a concept that is empirically testable (Mwcga *et at* 19XS). Granger causality test was used to test for temporal leads and lags of one anotlier. Causality is said to occur between groups of given stochastic variables only if the past predicts the present or the future given relevant information. Adding more information improves the predictability of some certain outcomes.

Testing lor causality containing lags of the dependent variable can be illustrated as

$$Y_t * I«n^{+}Y«-i +2WtrNk \quad \ldots \quad 3.1$$

The added information in predicting Y, is contained in the lagged values of X, and the error term. Therefore, testing for significance of the coefficients is done using the P-statistics; if o.», is identically zero, then \\ is predicted solely from its own past values and the stochastic term. Tl»e interpretation in this case will he that Xt does not granger cause Y. . Granger causality can also be tested in the reverse direction by specifying the equation below:

$$X \wedge V P n + X,., \quad Y. + e, \quad \ldots \quad 3.2$$

If the null hypothesis that P>- 0 is rejected, then it can be said X granger causes Y. The series of F-statistics after regressing equation 3.1 and 3.2 may give the follow ing oilcomes;

- One variable granger causes the other
- Both variables granger cause cach Oliver thus we have presence of feedback between them
- The variables do nol cause cach other hence ihere is no granger causalil). The response of feedback between X and Y implies that a shock on anv of these variables will peter out rapidly but will have permanent effects.

3.3.2 Error Correction Model

Error-correction models have been a popular form of macro model in recent years in which the change of one of the series is explained in terms of the lag of ihe difference between the series, possibly after scaling and lags of the differences of each series (Ghosh. 2002). Il is also particularly important in making the idea of cointegration practically useful. Data generated by such a model is sure lo be cointegrated.

The existence of cointegration relationships indicates that there are long-run relationships among the variables, and thereby Granger causality among them in at least one direction. T he LCM was introduced by Sargan (l%4>. and later popularized by Hngle and Granger (1987). It is used lor correcting disequilibrium and testing for long and short-run causality among cointcgrated variables.

The I CM used in this study is specified as follows:

AYi = u<j•«,//, i'^u..$_M$(i)Ayi, •Di»(i)A*.$_r$tc„ 3.3

Ax» = II,<a_r/i, I IU||(i)Ay,,. 3.4

Wliere Y, and X, represent natural logaritlum of real GDI' and electricity consumption, respectively, and (AY,. AX,) are the differences in these variables that capture their short-run disturbances. «:y,. ex, arc the serially unconvlated error terms, and m, i is the error correction term (L'CT). which is derived from the long run cointegration relationship - i.e. Y, |i,+|5iX,-m, and measures the magnitude of the past disequilibrium (it is called the lit! since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments), (Granger and Lngle. I'>87).

In each equation, change in the endogenous variable is caused not only by tl>eir lags, but also by the previous period's disequilibrium in level. Given such a specification, the presence of short and long run causality could be tested. Consider Equation 3.3. if the estimated coefficients on lagged values of electricity consumption arc statistically significant, then the implication is that the electricity consumption Granger causes real GDP in the short-run.

On the other hand, long-run causality can he found by testing the significance of the past disequilibrium term.

J.4 Stationarity of ilulu

rhis test is to identify stationarity in variables used. Stationarity is defined as a quality of a process in which the statistical parameters (mean ami standard deviation) of the process do not change with lime (Lnglc, 1987). live analysis of time scries data sets is not complete unless stationary data is used. If the non-stationary time scries data is used, it may lead lo conclusion whose validity is questionable. Ii is therefore important to test whether the data used is stationary or not before any data is comprehensively analy sed Moth graphical lest and the unit rool lest may be used to determine stationarity.

a) Graphical inspection method

I his method is also known as eye balling method whereby the ty pe of the graph will help determine the nature of stationarity. I his is done ideally by looking at the lines in the graph; that which settles along the centre continuously will be considered as stationary whereas the one that ascends/descends continuously will be considered as non-stationary. I he graphical results of this method arc shown in the appendix seetion II.

b) Unit RWI Tgsl

This test was done to reinforce and corroborate the results from the graphical inspection method, which sometimes does not show the exact nature of the stationarity The unit root test indicates whether the variables arc stationary or not.

This lest was necessary because lime series data requires transformation failure to which ihe problem of non-stationarity will arise and make the results have spurious regression. Ihe problem of non-stationarity arises in two ways. The variable in question can contain a deterministic trend or a stochastic trend (Granger and Lnglc, 1987).

The difference between the two is thai with a dctcrministic trend the growth of the variable can be predicted with certainty, which can either be linear or polynomial, but for a stochastic trcikl tl>c growth of the variable cannot be predicted with certainty. In testing for unit root two options were used: ADF and PP.

Ihe ADF lesl was specified by (Granger and Englc. 1987) ami it was performed by introducing lags of the dependent v ariables. To avoid spurious regression, the non-stationary variables were diffcrcnced to remove any stochastic trends in the series The ADF test took care of the intercept and the possibility of having residuals that were autocorrelatcd.

ADI regression model took the form of:

A t , M u * l*.VX_M *..3.5

This estimation procedure is similar to ihe Dl lest. Nevertheless, the DF assumes thai the data generating process is AR (I) process under the null. This is a major shortcoming of the DF test since if this is not the case, then autocorrelation in the error term in the equation biases the estimates. ADI is therefore adopted as the remedy of this shortcoming.

AY, • P W , + e ,..3.6

philip Perron (PP) lest was necessary to test for the presence of structural breaks in the variables. It applies formula (3.6) which is similar to that of Al)l in formula (3.5). PP also confirms tlx: unit root test given by AIM test. I he PP unit root test was utilised in this case in preference to ADF unit root tests for tl\c following reasons. I irst. the PP tests do not require an assumption of Itomosccdasticity of the error term (Phillips. 1987). Secondly, since lagged terms for the variable of interest are set to zero there is no loss of effective observations from the series (Perron 1988). which is especially useful if the number of data points is limited. The PP unit root test corrects the serial correlation and autoregressive heleroscedasticity of the-cm* terms by a technique called the Hartlett window This aims at providing unit root tests results that are robust to serial correlation and time dependent heleroscedasticity of errors.

Both the PP and ADK unit root tests were used where the null hy pothesis was that the series is nonstationary and this is cither accepted or rejected by examination ol the t-ratio of the lagged term Xt I compared with the tabulated values.

3.5 Cointegration analysis

The cointegration property is a long-run property, and therefore in frequency domain it refers to the zero-frequency relationship of the time scries. I hereforc. there is a frequency-domain equivalent of the time domain cointegration property. Specifically, existence of a cointegration relationship between two time series in the time domain imposes restrictions on the series zero-frequency behavior in terms of their cross spectral measures in the frequency domain t'oi integration of the variable implies that there must be an adjustment process to prevent the deviations from long run equivalent relationship from becoming larger and larger. In the e\ent of the non-stationarity of the series, a test of cointegration is conducted by apply ing ADF and PP tests to the residuals of the statistics cointegration (long run) regression rather than the levels of the series..

following the work of I ngle and Granger (1987) we specify the cointegration regression as,

J^-Clo+CI,*, « £|..3.7

I he residual of the equation c« _(x,- u« - «,/„ is simply the 1(1) series. If the residuals from the linear combination of non-stationarity series arc themselves stationary, then we accept that the l(I) scries is cointcgratcd and we shall take the residuals from the cointegrating regression as a valid F.CM which is then built into an F.CM In this case; test for cointegration; the critical values for the test will differ according to the number of variables in the cointegrating regression.

Cointegration implies tliat deviations from the data scries are blalionarv even though they themselves have infinite variance. The hypotheses are as follows;

I lo: no cointegration

III: cointegration exists

I he two-step test for cointegration proposed by Fngle and Granger (1987) examine long-run co-movement of the variables, first step tests whether the variables of unit Yt and Xt have a Stochastic trend . This is investigated by performing unit root test on the residuals of the variables. Second step tests whether stochastic trend sin these variables are related . this is investigated here by estimating the cointcgrating regressions of the form

I he logic behind the lest is that integrated variables are cointegratcd if their linear combination produces stationary residuals. The lest therefore assumes iliat there is one cointegrating vector described by the linear combination of the regression equation. Therefore, if the residuals from these regression equations are stationary, then there is cointegration among tl»e variables in the modd

This analysis combines both short-run and the long run properties and at the same time maintains stationarity in all the variables. Such an analysis tests the existence of long run relationship between an independent variable and its explanatory variable. II two or more variables are integrated of the same order and their differences have no clear tendency to increase or decrease then this will suggest tluit their differences are stationary. Thus if non-stationary series lu\e a long run relationship they will be stationary. If the linear combination of the residual from the variables is integrated of order zero 1(0). then this will be a ease of cointegration ((ireen. 2003) The existence of cointegration is important because failure to find cointegration between variables will be a manifestation of tlie existence of spurious regression in which case the valid influence will not be realized. I lie I ngle-Grangcr two-step procedure based on residual tests (ADF) was uscdio test for Cointegration.

I he error correction mechanism was therefore, used to test for the existence of a unique long-run cointegrating relationship between the variables under study (non-seasonally adjusted data). Deviations of both electricity consumption and economic growth were assumed lo be corrected in the long run. Thus testing for cointegration is a prerequisite lo causality testing

It should be noted that for data scries thai are found lo be coinlegraled. the vector error correction model (ECM) is established. The linding of coiniegraiion suggests the presence of persistent co-movements among ihe aggregates. While the estimates of cointegraiing relationship indicate direction of attraction thai maintain long run Stationary in the system. However they offer no information aboul adjustment speeds of variables to deviations from iheir common trend. I his question is addressed by incorporaiing an error correction term (l-CT).

In case cointegration is not found, then the granger causality lest can be done without loss of information. Granger (1983) sliowed lhal if asset of variables is comiegraied. Ihen il has an error correction representation, conversely, an error correction mechanism always produces a sel of variables that are coinlegraled. 1'his means lhal in the case of variables lhal move stochastically together over lime the LCM provides a parameterization, which in uddilion lo its olher merits is also capable of adequately representing time series properties of llic daia sets. Granger (1988) also pointed out lhal ifa pair of scries is cointegrated, then I he re musl be granger causation in at least one direction.

i.lt **Correlation test**

I his is a lest for serial correlation of the residuals because the Durhin Watson (DW) lesl is not efficient when higher lagged order of iIk depcndcnl variable is included us explanatory variable (Fngle and Granger. 1987). This study used I.angragian Multiplier (LM) method lo test lor serial correlation-'autocorrelation of the residuals. Unlike the Durbin-Watson statistic for AR(I) errors, the I VI test may be used to test for higher order ARMA errors, and is applicable whether or not there are lagged dependent variables. I'he serial correlation LM test is available for residuals from least squares or two-stage least squares. I he original regression may include AK and MA terms, in which case the test regression will be modified to take account of the ARMA

Therefore, it is recommended whenever OIK- is concerned with the possibility that errors exhibit autocorrelation, The formula applied is as follows;

A* = P o + M X h + M...3.8

In addition, the hypothesis in LM is set similar to the ADF as follows:

The null hypothesis: I lo:u.>0 Non Stationary (Unit Root Presence)

Alternative hypothesis: Ht: U<1 Stationary (No unit root)

The null hypothesis of the I M test is that there is no serial correlation up to lag order p. where p is a prc-spccified integer. The local alternative is ARMA (r.q) errors, where the number of lag terms p = max!r.q}. Note lhal Ihe alternative includes both AR(p) and MA(p) error processes, and that the test may have power against a v ariety of autocorrelation stnictures. See Godfrey (1988) for a discussion.

Ihe test statistic is computed by estimating an auxiliary regression (regression of the residuals) on the original rcgrcssors X and lagged residuals up to order p. The F.Views package used in this study reports two test statistics from this test regression. The F-statistic is sin omitted variable test for the joint significance of all lagged residuals. Because the omitted variables are residuals and not independent variables, the exact finite sample distribution of tlie F-statistic under is not known, but was still presented for comparison purposes. The *Obs*K-squared* statistic is the Brcusch-Godfrey LM test statistic. This l.M statistic was computed as the number of observations (uncentered) from the test regression Under quite general conditions, the LM test statistic is asymptotically distributed as a (p).

Rejecting the null hypothesis would mean that the series is stationary and vice versa. Accepting the null hvpothesis implies that the variable has a unit root or is a random walk variable and hence is non-stationary. If «<1. the process generating Y, is integrated of order zero and hence stationary 1(0).

3.7 Diagnostic tests

The diagnostic or specification tests aie typically used as a means of indicating model inadequacy or failure. They arc also necessary to indicate whether tlx: models arc consistent, properlv specified and whether there is no serial correlation of the disturbance term across time periods. In this study the tests were used to verify the effectiveness of the model relationship between electricity consumption and GDP. The tests included residual tests for normality, serial correlation. ARCH effects, and hetcrosccdasticity. There were also stability tests done that included chow breakpoint, chow forecast, Ramsey Rl SI I and CI SUM tests, which played a role in the model evaluation stage. These tests were used to for test parameter stability in the absence of apriori information about tl>e exact timing of a structural break

In this Study, the stability of the models of the relationship between electricity consumption and GDP were tested, with each taken as the dependent variable alternatively.

Normality tests were used to cheek the set of data for similarity to the normal distribution with the null hypothesis being that the data set is similar to the normal distribution. Normal distribution generally takes the form of a symmetric bell-shaped curse and is assumed by many statistical procedures (Granger and F.ngle, I'>87). Normality test utilizes I Ik- mean based coefficient of skewness and kurtosis to chcck the normality of all the variables used. Non-normality of the variables may affect the normality of the resultant residuals, may be associated with the presence of heteroscedasticily and may highlight outliers. Since most macrocconomic variables are log normally distributed and the models in his study are in logarithmic form, normality tests were done for both raw data and data in logarithmic form. Normality test used the null hy pothesis of normality against the alternative hy potliesis ol non-normality. Under the histogram testing, the null hypothesis of a normal distribution is . as a rule, accepted if the graph indicates a normal spiead

The autoregressive conditional heteroskedastieity (ARCH) test is a I angragiun Multiplier <LM) test for ARCH in the residuals. Ignoring ARCH effects may result in loss of efficiency. I his is a particular specification of heteroskedastieity motivated by the observation that in many time series the magnitude of residuals appear to be related to the magnitude of recent residuals (Granger and Engle. 1987).

I he Whiles Hctcroscelasticity lest is a test for heteroskedasticity in the residuals from a least squares regression (Green. 2003). Ordinary least squares estimates are consistent in the presence heteroskedasticity, but tin; conventional computed standard errors are no longer valid. White's test is a test of the null hypothesis of no Itetcroskedasticity against heteroskedasticity. The probability value of the F-statistic is hence used in the analysis. If the probability value is less than 0.05. reject the null hypothesis.

fhc idea of the breakpoint Chow test was to fit the equation separately for each subsample and to see whether there arc signilicant differences in the estimated equations. A significant difference indicates a structural change in the relationship. I he Chow forecast test was used to estimate the model for a subsample comprised of the first observ ations, The estimated model was then applied to predict the values of the dependent variable in the remaining data points. A large difference between the actual and predicted values casts doubt on the stability of the estimated relation over tin: two subsamplcs. set at chosen period.

The F-statistic is based on the comparison of the restricted and unrestricted sum of squared residuals and is the simplest case involving a single breakpoint. The log likelihood ratio statistic is also based on the comparison of the restricted and unrestricted maximum of the (Gaussian) log likelihood function. The I.R test statistic lias an asymptotic distribution with degrees of freedom equal to (m-l) k under the null hypothesis of no structural change, where m is the number of subsamplcs.

The Ramsey RF.SH1 (Regression Specification Error) Tesi was used to detect specification error in an equation which was known apriori to be misspeciftcd but which nonetheless gave satisfactory values for all the traditional lest criteria goodness of lit. test for first order serial correlation, high t-rutios. It is a general lest for the specification errors that include omitted variables, incorrect functional form, correlation between X and Y. simultaneous equation considerations and serially correlated disturbances.

I he CUSUM test was based on the cumulative sum of the recursive residuals. This option plots the cumulative sum together with the 5% critical lines. This option plots the cumulative sum together w ith the 5% critical lines. Any movement of residuals outside the standard error bands i.e. outside the critical lines is suggestive of parameter or variance instability in the model equation.

I he above diagnostic tests were applied to the regression models identified for the relationship between GDP and electricity consumption to verify tlw effectiveness of the model relationship.

3.8 Data

I he data (as shown in Table AI in Appendix I) used for the analysis is time series that covers the period from 1970 to 2004. Nominal GDP and electricity consumption data were obtained from the liconomic Surveys, Statistical Abstracts and KPI.C Annual Reports and Accounts expressed in terms of million Kilovvatt-llours (Kwh) and million Kenya Shillings, respectively.

CHAPTER FOUR

EMPIRICAL RESULTS

1.1 Introduction

In this chapter the conccpts of cointegration. Granger Causality and Enor Correction Model were applied to achieve the objectives as stated in chapter one. By using recently developed econometric techniques related to cointegration of economic time series and dynamic specifications associated with ECM. the problem associated with non-stationary variables were tacklcd. This chapter starts with testing for normality followed by stationarity and then cointegration.

4.2 Stationarity of data

Based on the graphs and unit root test in the appendix III (Figure A1. A2, A3 and A4). it was found that electricity consumption and economic growth data become stationary after differencing. However, the difficulty to determine the order of integration was soned out by a more formal test for stationarity (a unit root test) to mitigate the inadequacy of the graphical methods

b) Unit Root test results

The unit root results arc shown in table 4.1 below in terms of forms of the data, which was at level and first difference. The t-statistics and the critical values at 5 percent level ofsignificance arc also shown for comparison purposes.

The results indicated that the electricity consumption and GDP data sets were non-stationary because the ADF/PP t-statistics was greater than the ADF t-critical at 5% level of significance. I his created several econometric problems such as possibilities of spurious regression and inconsistent estimates from a regression.

I able H AD! and I'P I nit Root I est results

Variable	Test	Form		lest Statistic	5 % Critical vuluc	Decision
Electricity	ADF	C	Level	-0.466	-2.950	Non-Stationarv
		C & T	1° difference	-N.261	-2.953	Stationary
	PP	C	Level	0.001	-2.950	Non-Stationary
		C & T	)* difference	-9.926	-2.953	Stationary
GDP	ADF	C	Level	-0.951	-2.950	Non-Stationarv
		C & T	1u difference	-9.377	-2.953	Stationary
	PP	C	Level	-0.994	-2.950	Non-Stationarv
		C & I	1J difference	-6.356	-2.953	Stationary

Where C constant
C & I • constant and trend

I he results at level specified that the ADF PP t- statistics was less than the t-critical values and therefore the null hypothesis of non-stationarity was rejected and that the series were stationary at 5 percent level of significance. The results after first differencing of the variables is stationary as indicated by the statistics which were compared with the critical values at 5 percent level of significance which implies that these variables arc integrated of order one. *HI).*

The graphs and the unit root test of these stationary series arc shown in Appendix III AI to A4. It should be noted that differencing of the data to make them stationary may lead to loss of important information regarding long run equilibrium relationship between the variables, fo overcome the drawback, cointegration analysis was performed.

1.2 Granger Causality Analysis

I he null hypothesis tested was that Electricity Consumption docs not Granger-cause GDP in the first regression and that GDP docs not Granger-cause I leetricity Consumption in the second regression.

I able 4.2 Granger Causality test results

Null hypothesis	No. of lags	F-statistics	P-value
Electricity consumption does not granger cause GDP	0	3.44	0.03
Electricity consumption docs not granger cause GDP	1	3.54	0.02
Electricity consumption does not granger cause GDP	-)	4.17	0.03
Electricity consumption docs not granger cause GDP	3	6.62	0.04
Electricity consumption does not granger cause GDP	4	5.88	0.05
1 lectricity consumption docs not granger cause GDP	5	3.43	0.05
Electricity consumption does not granger cause GDP	6	4.48	0.01
GDP docs not granger cause Electricity consumption	0	3.87	0.03
GDP does not granger cause Electricity consumption	1	6.54	0.02
GDP does not granger cause Electricity consumption	2	4.54	0.05
GDP does not granger cause Electricity consumption	3	8.26	0.03
GDP does not granger cause Electricity consumption	4	4.31	0.04
GDP does not granger cause Electricity consumption	5	3.91	0.01
GDP does not granger cause Electricity consumption	6	6.54	0.02

F (0.01) -5.39 I-(0.05) 3.32

Rased on the probability values reported, which arc significant and I -statistics from the above Table 4.2. the null hy potheses that GDP docs not granger cause Electricity consumption and that Electricity consumption does not granger causes GDP were both rejected. At 5 % level of significance, all the lag lengths tested showed bidirectional causality between GDI' and electricity consumption. Therefore, it can he safely concluded that causality runs both ways.

4.4 Model selection criteria

The reason lor choosing the appropriate lag structure of the variables in the model was to uddrcss the problem of while noise cncountcrcd in estimating F.C'M when different combinations of lags are used. Both Akaike Information (AIC) and Schwar/ (SBC) criteria were applied to decide on the number of lags for identifying the appropriate model. I bis was because Alt' and SBC criteria have been widely used in time scries analysis to determine the appropriate length of ihe distributed lag. Smaller values of the AIC/SIK' are preferred.

I able 4.3: Results ol lag length selection for clcclricity consumption model

1 ag length	AIC	SBC
0	2.36	2.45
1	2.33	2.42
2	2.36	2.45
3	2.39	2.49
4	2.38	2.46
5	2.37	2.48
6	2.39	2.45

From the table 4.3 it can be deduced that lag length of one returns the lowest values for the set criteria hence the electricity consumption model will use the first lag.

Table 4.4: results of lug length selection for economic growth model

Lag length	AIC	SBC
0	3.06	3.15
1	3.09	3.18
2	3.10	3.19
3	3.13	3.24
4	3.16	3.25
5	3.15	3.27
6	3.18	3.29

From the table 4.4. it can be deduced that distributed lag of one returns llic lowest values for tlie set criteria hence the economic growth (GDP) modsI used the lirsi lag.

From tl»e above Alt ainl SBC results the data analysis was done using the Autorcgressive Distributed I ag (ADL) model given tlut the suitable lag to be used was one lag. This implies that the de|>cndent variable and the independent variables have been lagged once i.e. both the dependent and additional predictors (variables) have been lagged in this model. The nature of the model is Y f(X. Y,.|). and specifically the regressions were modelled as follows;

i. lilcctricity (onsumption = f (GDP. Electricity Consumption lagged once) and
ii. GDP f(I lectricity Consumption. GDP lagged once).

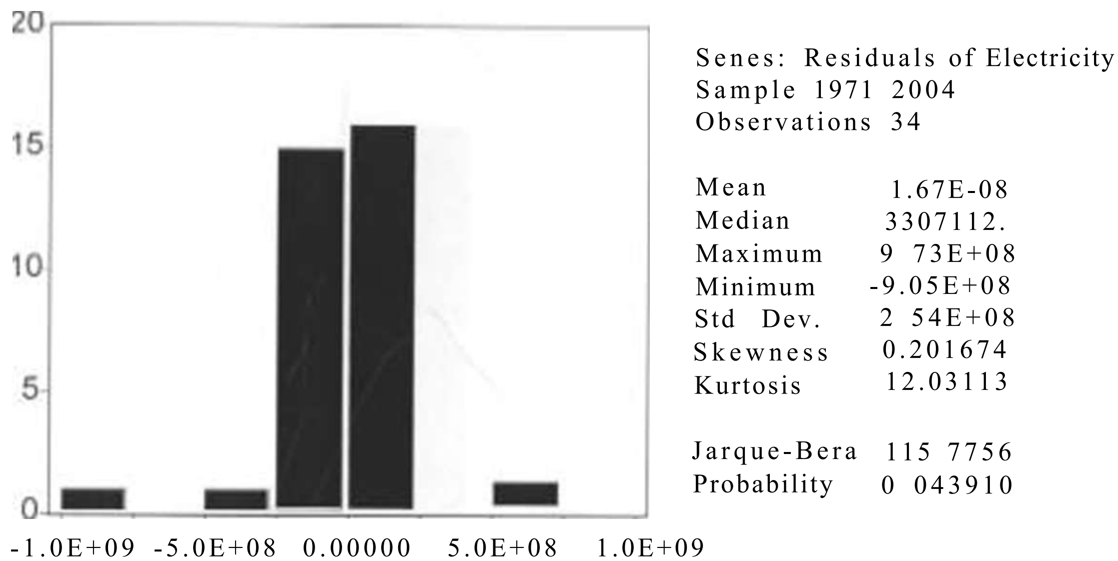
4.5 **Diagnostic test for regression residuals of the estimated models**

4.5.1 **Residuals tests**

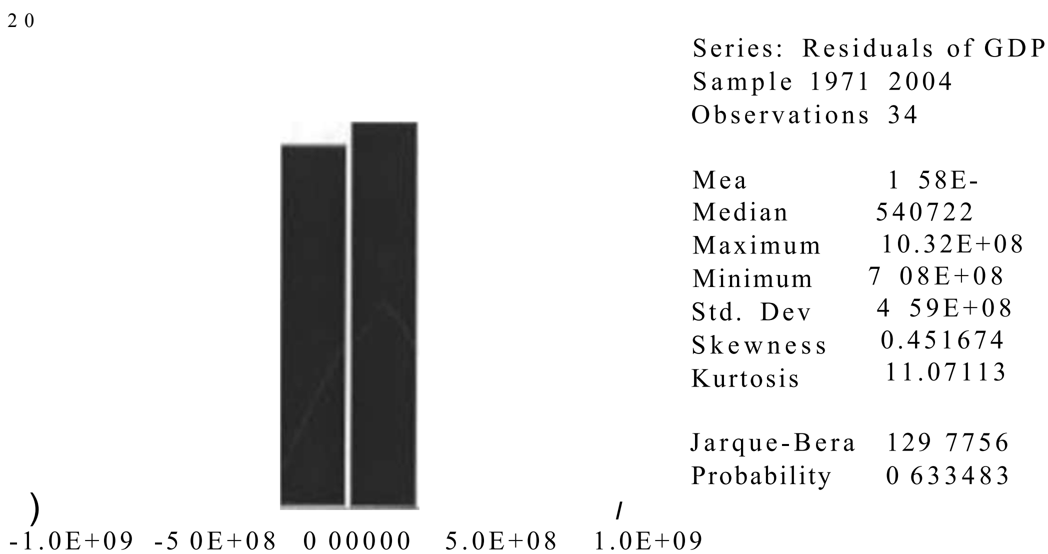
a. <u>Histogram Normality lest results</u>

This test display s a histogram and descriptive statistics of the residuals, including the Jarque-Bera statistic lor testing normality. If the residuals are normally distributed, the histogram should be bell-shaped and the Jarque-Bera statistic should not be significant

I imirc I: Histogram digram for electricity consul



I rom the above diagram, it was concluded that the error term of electricity consumption data series are normally distributed given that the Jarque-Bera statistics is not significant at 5% level of significance and that the histogram shows a normal distribution. I licrel'ore. the regression to be obtained obeys the OF S assumption of consistency and efficiency



From ilic above diagram, it was concluded dial the residuals of economic growth (GDP) data series arc normally distributed given tliat IIK- Jarquc-Bcra statistics is not significant at 5% level of significance. Therefore, the regression to obtained obeys the Ol.S assumption of consistent and efficiency.

h serial Ci'nvktUttn KM rg^|ts

I able 4.5: Correlation lest results using Breusch-Godfrey Serial Correlation I M Test

Correlation tesi result lor GDP			
I -statistic	2.313	Probability	0.028
Obs* l<-squared	4.975	Probability	0.026
Correlation lest result for I leetricity Consumption			
F-siatistic	3.215	Probability	0.028
Obs'R-squared	7.946	Probability	0.019

From the Ureuseh-Godfrey LM test result table 4.5 above, the P-values off-statistic for both cases are not significant at I percent significant level and therefore the null hypothesis is not rejected, hence there is no serial correlation. Additionally comparing the I M test results above with the critical chi square statistic (0.95. I) of 3.84 (obtained from y tables) for the first order serial correlation of residuals, no serial correlation problem is revealed.

c. ARCI-I Residual lest

I able 4.6: ARCH results

ARCH results lor GDP			
l-statistic	2.823	Probability	0.091
()hs*R-squared	6.586	Probability	0.010
ARCH results lor Electricity Consumption			
l-statistic	1.032	Probability	0.060
Obs[4] R-squared	0.034	Probability	0.038

I rom the ARCH test result above, the calculated I-statistic for both variables is less than the I -critical of 3.32. the null hypothesis is thus not rejected, and hence there is no ARCH effect in the residuals, litis implies that the model is efficient since there is no conditional hctcroskcdascticity between residuals and the previous residuals.

d. White Hcteroscedasticitv Test

I his test was performed to address the problem encountered when using LCM to choose the correct lag structure of the variables in the model. I he results on the hclcrosccdasticity test arc shown below.

Table 4.7: W hite Hclcrosccdasticity Test Results

Whites Hctcroskcdasticity Test for residuals of GDP			
F-statistic	0.155	Probability	0.857
Obs'R-squared	0.338	Probability	0.845
Whites Hctcroskcdasticity Test for residuals of Electricity Consumption			
F-statistic	1.432	Probability	0.254
Obs*R-squared	2.875	Probability	0.237

Since all the p-values of the residual both for electricity consumption and economic growth, are greater than 0.05 implying insignificance at $ percent level of significance and the I - statistics are less than the critical value indicating no rejection of the null hypothesis, heterosccdasticity is thus not a serious problem. Hence, the OLS estimator in the model between electricity consumption and GDP is unbiased, consistent, efficient ami inference procedures arc valid.

4.5.2 Stability' tests

a. Chow break point test 2000

Table 4.8: Chow break point test

Chow break point test. 2000 for GDP			
F-statistic	0.067	Probability	0.935
l.og likelihood ratio	0.155	Probability	0.926
Chow break point test 2000 lor Electricity Consumption			
F-statistic	0.447	Probability	0.644
Log likelihood ratio	1.001	Probability	0.606

From the Chow test results for the respective I-statistics and its probability of 0.06 and 0.85 for GDP and 1.43 and 0.25 for Electricity Consumption, it was noted that both of the breakpoint test statistics do not reject the null hypothesis of no structural change in the relationship from the stated year (2000). Therefore, it implies there was no structural change over the period 2000-2004. and that the pooled regression estimated is the best with stable coefficients.

b. (how forecast lest: Forecast from 2000 to 2004

Table 4.9: Chow forecast Test

Chow forecast l est: Forecast from 2000 to 2004 for GDP			
F-statistic	0.370	Probability	0.997
Log likelihood ratio	0.199	Probability	0.995
Chow forecast lest: forecast from 2000 to 2004 lor Electricity Consumption			
F-statistic	2.256	Probability	0.903
Log likelihood ratio	1.228	Probability J	0.873

Testing the similar hypothesis using the CIKJW forecast as indicated in the above table it was found that neither of the forecast test statistics. (F-statislics of 0.37 and its probability of 0.99

for GDI' and 2.25 and its probability of 0.90) rejected the null hypothesis of no change in stability of the estimated relations over the two subsamples before and after the year 2000. Besides, thee probabilities indicated that the forecast regressions were not statistically significant.

c. Ramscv RF.SM test for GDP

I able 4.10: Ramsey RF.SI I I est

Ramsey RLSLI test for GDP			
1 -statistic	0.480	Probability	0.759
Log likelihood ratio	1.083	Probability	0.802
Ramsey Rl SI T test for Electricity consumption			
F-statistic	1.194	Probability	0.924
Log likelihood ratio	0.439	Probability	0.032

From the table 4 10 above the observed F-statistics is less than the l'-critical. at 5 % level of significance i.e. I (2. 32) of 3.32. the decision made was not to reject the null hypothesis and to conclude that there exists no non-linearities i.e. the disturbance is presumed to have a normal distribution. Iheretore. the model between electricity consumption and GDP was correctly specified

d. CUSI. M lest lor Electricity Consumption

As noted in the methodology scction. the CUSUM test finds parameter instability if the cumulative sum goes outside the urea between the two critical lines. Any movement outside the critical lines is suggestive ofcoefficient instability.

figure 3: CI 'SI VI test lor Electricity Consumption

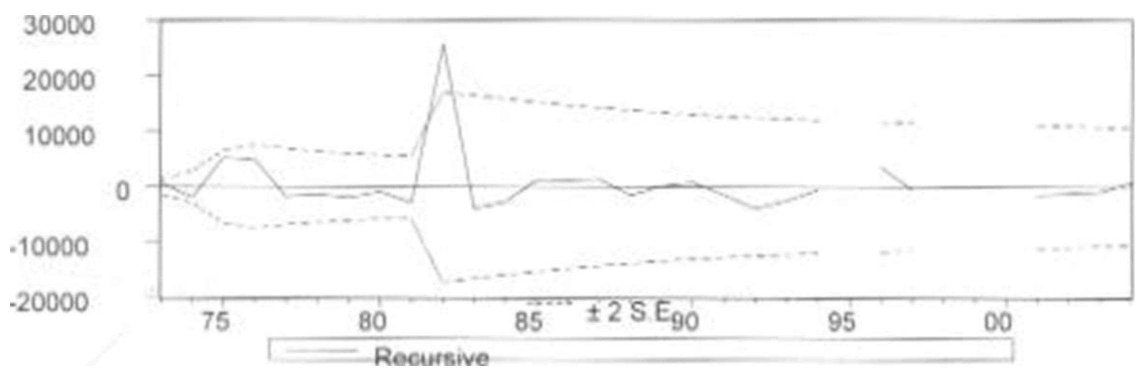
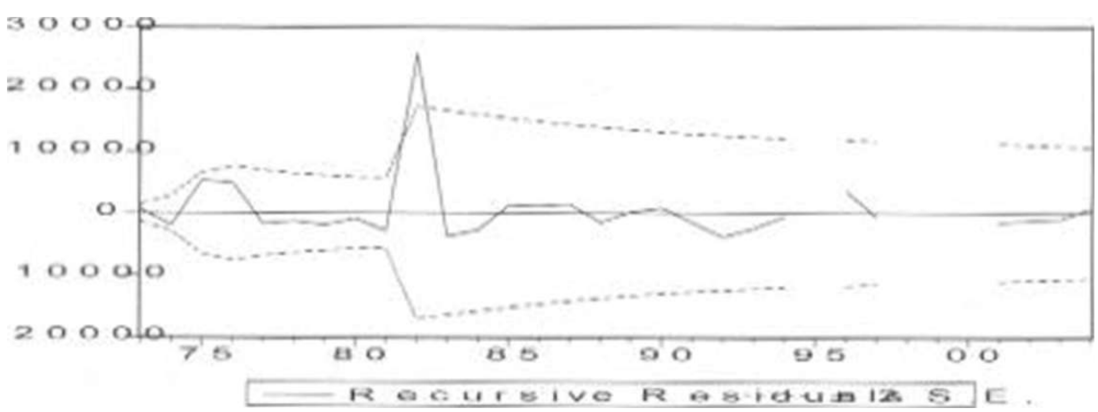


figure 4: CUSI VI test lor GDP



I 'rom the above two graphs show ing the CUSUM test results for the regression models of the two variables, the test found the parameters stable given that the cumulative sum do not go outside the area between the two critical lines. Therefore, it is suggestive of coefficient stability tor both electricity consumption and GDP regression models.

4.6 Model **Estimation Results**

I able 4.11: Model estimation results for GDP

Independent variable	coefficient	t-statistic	P-value
Constant	0.834	0.901	0.001
GDP lagged once	2.153	6.732	0.011
1 lectricity consumption	1.018	4.048	0.021
Electricity consumption lagged once	6.437	3.967	0.344
Error Correction Term	0.801	9.247	0.000

Adjusted R squared - 0.78 DW= 2.09 F-statistic 2,78 Probability (F statistic) 0.000

SI R 1.1709 DF =32

I he table above presents the model estimation where GDP is the dependent variable and electricity consumption. GDP lagged once and electricity consumption lagged once are the explanatory variables with coefficients 1.01. 2.15 and 6.43. respectively. I he ECT coefficient of 0.80 is statistically significant at 5 percent level of significance and stable. This reflects the direction ami speed ofadjustment in the dependent variable to any temporary deviations in the system. The adjusted R squared (0.78) implies a 78 percent explanatory power of the independent variables. DW statistic of 2.09 means no serial correlation among residuals, and the SF.R indicates a minimal level of deviation.

I able 4.12: Model estimation results for Electricity Consumption

Independent variable	coefficient	t-statistic	P-value
Constant	1.847	0.628	0.315
Electricity consumption lagged once	7.407	2.657	0.191
GDP	3.005	9.048	0.096
GDP lagged once	4.115	7.985	0.030
Error Correction 1 erm	0.781	1.563	0.000

Adjusted R squared 0.67 DW-2.23 F-statistie 2.108 p-value (I statistic) - 0.0000

SER >0.660218 l)F 32

Like in the regression model estimated for GDP, the table above presents the estimation for Electricity consumption as the dependent variable and GDP, electricity consumption lagged once and GDP lagged once as the explanatory variables with coefficients 3.00. 7.40 and 4.11, respectively. I he EC I coefficient of 0.78 is statistically significant at 5 percent level of significance and is stable. This reflects the direction and speed ofadjustment in the dependent variable to any temporary deviations in the system. I he adjusted R squared (0.78) implies a 78 percent explanatory power of tlic above-mentioned independent variables. DW statistic of 2.23 signify no aUoconclation, and the SER indicates a minimal level of deviation

The Error Correction Model estimations presented above follow in the footsteps of various studies undertaken using I CM to establish the nature of the relationship between electricity consumption and economic growth. These include; Shiu and Lam (China-2004), Asafu-Adjaye (India. Philippines and Ihailand - 2000). Glasure and Lee (Singapore and South

Korea -1997) and Masih and Masih (Pakistan - 1996) and Yang (Taiwan - 2000) who found a bidirectional causality relationship between electricity consumption and economic growth.

I lie two model estimations have common interpretations given their corresponding variables and coefficient estimates. From both FCM operations, a long run causality was found from electricity consumption to real GDP and also from GDP to electricity consumption. An error Correction Term (ECT) formed with elements of the reintegrating equation thus fitted at a single lag (ADL. I) to address the problem.

The LC'M model estimations specified the nature of the models from dual perspectives. First of all. where electricity consumption is the dependent variable and GDP the explanatory variable (Table 4.12). and secondly, where GDP is the dependent variable and electricity consumption is the explanatory variable (Table 4.11). It was noted that the FX I coefficients, which are statistically significant at 5 % level are stable 0.80 and 0.78 for Electricity consumption and GDP. respectively rcficct the direction and speed of adjustment in the dependent variahle to any temporary deviations from the relationship within tlie system. Generally, every deviation in the respective dependent variable is •corrected' by increase in output'usage of tl>e otlier.

Results of the significance of interactive terms of change in Electricity consumption and GDP. along with the I rror Correction Term in both models were found to be consistent with the presence of Granger-causality running from electricity consumption to real GDP and vice versa. This means that whenever there is the presence of a shock to the system, electricity consumption would make short-run adjustments to re-establish long-run equilibrium. The same applies on the GDI' which would readjust to propel electricity usage to the equilibrium position.

The results of table 4.11 show the LCM model lor GDP. The coefficient of log linear GDP lagged once (2.15) and for electricity consumption (1.01) and for electricity consumption lagged once (6.43) are found to Ik significant at 5% level of significance The l)\V statistics is Shown as 2.09. which signify that there is no serial correlation among the residuals. Both t-statistics and the probabilities of I -statistics imply that on average all tl»e coefficients of lite variables of the LCM analysis are jointly significant at 5 percent and explain the variations.

I ike for Ihe modelling lor GDP. the results show the LCM model for electricity consumption. I he coefficient of log linear electricity consumption lagged once (7.4) and for GDP (3.0) and for GDP lagged once (4.11) arc found to be significant at 5% level of significance. The DW statistics is shown as 2.23. which signify that there is no serial correlation among the residuals

I he adjusted R squared, which measures the til of the regression for ihe variables show that electricity consumption level and GDP have about 67 and 73 percent explanatory power for each other. I he results can be interpreted to mean that the changes in level of economic growth depend on electricity consumption. Additionally, changes in level of consumption of electricity in the economy are triggered by LIK- level of economic growth. I he adjusted R^2 is less than Ihe DW signifying that there is no spurious regression.

I he Standard I rror of Regression (SI R) columns gives the forecast error of the variables. The figures of 1.17 for GDP and 0.66 for electricity Consumption obtained from both LCM models above show a narrow spread of errors that occur in the model specified and that the estimation is accurate when log linear modelling is fitted.

Error Correction Term (LiCT) captured the convergence of the long run relationship. The levels of electricity consumption and GDP in the previous period will significantly determine the levels of electricity consumption and GDP in the current period. I he coefficient on lagged R I included in the model is a speed ol adjusted coelVicienl that captures the dynamics between cointcgrating scries. The coefficients of ECT in both models are positive and statistically significant at five percent. It indicates speed of adjustment of approximately XI) percent from the actual level of GDP and Electricity Consumption in the previous year to the equilibrium rate of GDP and Electricity Consumption. The speed implies that the variables converge to the long run equilibrium relationship.

Given the bidirectional long-run equilibrium relationship between electricity consumption and economic growth with 67 percent and 73 percent explanatory power on each other, this study concurs with several works as outlined in the empirical literature review. The empirical works also applied both error correction mechanism and granger causality approacltes to Asian countries such as Singapore, Thailand. South Korea, and Pakistan among others and established bidirectional causality and long run equilibrium relationship between electricity consumption and economic growth.

CHAPTER FIVE

CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction

This scction presents ihc summary of the study and the findings rcached after the data analyses and regression of the variables mentioned in previous chapter. Areas with probable policy suggestions are identified and explained as indicated in the objectives of the study section. It also shows the areas of further research related to the topic discussed

5.2 Summary

The study set out to determine the existence of causality between electricity consumption and economic growth in Kenya, to determine the short run or long run equilibrium in the relationship between the variables, and to model the relationship between electricity consumption and economic growUi. Both Granger Causality and Error Correction Model (ECM) were applied to achieve the above specific objectives. Prior to testing for causality, stationarity and diagnostic tests were undertaken. The time scries data for both annual electricity consumption and GDP were obtained from government publications for the years 1970-2004.

In testing for the direction of causality a three-stage procedure was followed. In the first stage the order of integration was tested using the unit root tests. I he second stage involv ed testing for the existence of a long-run equilibrium relationship. The ADF and PP were employed to test for cointegration on residuals.

The third stage involved constructing standard Granger-type causality tests augmented with a lagged error-correction term where the scries are cointegratcd. The Granger-type causality test on the dependent variable for electricity consumption and economic growth was augmented with a lagged error-correction term.

The existence of a cointegrating relationship between electricity consumption and economic growth suggested that there was Granger causality in at least one direction, but it did not indicate the direction of temporal causality between electricity consumption and economic growth. The t-statistic on the coefficient of the lagged error-correction term indicates the statistical significance of the long-run causal effect and hcnce the model regression identified for both electricity consumption and economic growth.

5.2 Conclusion

Estimation results from the Granger causality analysis indicated that there is a bidirectional relationship running from electricity consumption to real GDP and vice versa thus an increase in electricity consumption would raise real GDP while improved economic growth would trigger higher electricity consumption. This direction of causation shed light on future electric energy policies regarding environmental protection, generation, transmission and distribution. The empirical findings support earlier studies by Shiu and Lam (2004) for China Masih and Masih (1996) for India, Asafu-Adjaye (2000) for India, Glasure and Lee (1997) for Singapore and South Korea and Yang (2000) for Taiwan, all who found a bidirectional relationship between electricity consumption and economic growth, highlighted in the literature section, which advocated for the notion of mutual relatedness between electricity consumption and economic growth.

From the error correction analysis, it was established through the coefficient of PCT, which was found to be stable, that there is a long run equilibrium relationship between electricity consumption and GDP. Results of significance of interactive terms of change in both variables, along with the ECT in either of the two regression equations were established to be consistent with the presence of bidirectional Granger causality I his implies that whenever there is a shock to the system, short run adjustments occur to re-establish long run equilibrium between electricity consumption and GDP.

5.2 Policy implications

In policy terms, the investigations on the relationship between electricity consumption and economic growth in Kenya call for expanded electricity network and power usage across the country, economic growth is expected to rise concurrently besides with an enhanced economic growth, electricity consumption in the productive sectors of the economy is expected to rise,

From the study it is also noted that electricity plays a key role in driving economic growth and therefore it calls for greater investment sourccd from either the national fiscal budget or through private sector participation and supplemented through development partnerships,

In order to overcome the constraints on electricity consumption, the Kenyan government has to speed up the nation-wide interconnection of power networks, to upgrade urban and rural distribution grids, and to accelerate rural electrification. I Ik-sc policies will have the effect of improving the efficiency in power transmission and distribution, alleviating the problem of power shortages, and allowing the rural population lo enjoy a higl>er level of electricity consumption when the economy of Kenya continues to achieve remarkable growth.

5.J Limitations of the study and areas for further research

Despite the efforts on ensuring the study is complete, it should be conceded that the study lias some limitations since data collection and measurement may noi have been accurate. It is likely that measurement errors were obtained in the national account data, therefore, availability and lite quality ol'data are the main constraints of the study.

I or further research, there is need to explore the specific role played by the electricity sub sector in poverty alleviation and economic growth, considering other key variables. This calls for an elaborate model that captures all variables, which affect both electricity consumption and economic growth. Policy researchers could also delve into investigating the key determinants of electricity usages and measures to improve on its delivery.

BIBLIOGRAPHY

AFREPRF.N (1992). *Rural electrification in Africa..* Nairobi: AFRFPRFN

AFREPRFN (2004). *African Energy Data Handbook.* Occasional Paper 23. Nairobi: AI REPRFN.

AFREPREN (2005). *Do the I'oor Benefit from /'oner Sector Reform> Evidence from East Africa* Occasional Paper No. 25. Nairobi: AFREPREN.

Amman II. (I969). *Energy Supply and Economic Development In East Africa* New York: Humanities Press

Anaman. F. (2000). *Energy Use by Rural Households in Ghana A Case Study of the Impact of Rural Electrification.* Accra: Unpublished MA Thesis.

Asafu-Adjaye. J. (2(MX». *The Relationship between Electricity Consumption, Electricity Prices and Economic Growth: Time Series Evidence from Asian Developing (ountries.* Energy Economics. 22. 615 - 625.

Bcijcr Institute (1984). *H ood Energy and Household Perspectives in Rural Kenya.* Lund: Bcijer Institute

Central Bank of Kenya (2005). *Monthly Economic Review.* Nairobi. CBK

Cheng. B.S., l.ai. T.W., (1997). *An investigation of Co-integration ami Causality hetneen Electricity Consumption and Economic Activity in Taiwan* Energy Economics. 19.435 - 444.

Dickey. D.A.. Fuller. W.A- (1979). *Distribution of the Estimators for Autoregressive Time Series with a Unit Root.* Journal of the American Statistical Association 74. 427-431.

F.ngle. R.I'.. Granger. C .W.J. (1987). *Cointegration and Error Correction: Representation Estimation, and Testing,* Economctrica 55. 251 - 276

Irol. U.. Yu. E.S.H. (1987). *On the Relationship between Electricity and Income for Industrialized Countries.* Journal of Electricity and Employment 13, 113 - 122.

Ghosh, S. (2002). *Electricity Consumption ami Economic Grow th in India* I nergy Policy 30, 125-129.

Glasure. Y.U.. Lee. A.R. (1997). *Cointegraiion. Error Correction, and the Relationship between GDI' and Electricity: The Case of South Korea ami Singapore* Resource and I lectricity Economics 20. 17 25.

Goldeinberg. J., and T. It. Johansson (1995). *Overview: Energy as an Instrument for Soi io-Economic Development* in J Goldemherg & I. B. Johansson. eds.. Energy as an Instrument for Socio-Economic Development, New York: UNDP.

Goldembcrg. J. (2000) *World Energy Assessment Energy and the Challenge of Sustainahility* New York: UNDP-WEC.

Hwang. D.B.K.. Gum. B. (1992). *The Causal Relationship between Energy and GNT I he Case of Taiwan* I he Journal of Energy and Development 12.219 226.

International Energy Agency (IEA) (2003). *Energy Statistics of Non-OECD countries (IW)-2000f.* Paris: I LA.

Institute of Economic AtYairs (2005). *Reviewing the Electric Power Supply and tariff Policy"* in the POINT Maga/inc Issue No. 56. Nairobi: IEA

International Energy Agency (20O4) *International Energy Outlook* www.eia.doe uov accessed 15 Oct 2005

International Energy Agency (2002). *Sustainable Development on the Energy Sector* l»p 11-12. Paris: LIA

Jama. VI.A. (1987). *Impact of Rural Energy Costs* tfc *Availability in Kenya.* PhD thesis. Washington State University

Jhigon M. L (2004). *The Economics of'Development and Planning.* 4 edition. New Delhi

Jumhe, C.B.L., (2004). *Cointegration and Causality between Electricity Consumption and (iDP: Empirieal Evidence from Malawi.* Energy Economics 26. 61 68.

Kamfor Consultants I td & Ministry ol" Energy (2002). *Study of Kenya's Energy Demand. Supply and Policy Strategy for Households. Small Scale Industries and Service Establishments* Nairobi: Kamfor.

Kaieke/i. S.. Mapako. M.. ami lefcrra. M. (eds) (2002). *Energy Policy Journal - Special Issue-. Vol 30. 11-12.* Oxford; Elsevier Science Ltd.

Kareke/i. S. (2002). *Renewable*' in Africa-Meeting the Energy .Weeds of the Pour.* Energy Policy Journal Special Issue. Vol 30, 11-12. Oxford; Elsevier Science Ltd.

Kareke/i. S. and Mutiso. I). (2000). *Power Sector Reform A Kenya Case Study In power sector reform in sub-Saharan Africa.* I ondon; Macmillan Press.

Kareke/i. S.. Kimani. J.. Mutiga. A., and Amenya, S. (2003). *Energy Services for the Poor in East Africa.* Unpublished paper prepared forGNESD. Nairobi: Al REPREN.

Kareke/i. S. (2002). *Poverty ami Energy in Africa - A Hrief Review.* Energy Policy Journal - Special Issue. Vol 30. 11 - 12. Oxford; Elsevier Science I .id.

Kenya Power and Lighting Company *(KPLC), Annual Report and Accounts,* various issues for the period 1984-2004: Nairobi: KPLC.

kimuyu. P. (1988). *Demand for Commercial Energy in Kenya. 1963-1985: A Structural Investigation* Unpublished PhD thesis. University ofNairobi.

Kraft J., Kraft. A. (1978). *On the Relationship betw een Energy am! (JSP. Journal of Energy Development 3. 40! - 403*

Leigh O.K.. Park R.W and Prelum K.R (1979). *Energy and Development. A Preliminary Analysis for lew Dewto/H-d Countries* MITRF. Corporation.

Masih. A.M.. M. Masih, R.. 1996. *Electricity Consumption. Heal Income ami Temporal Causality Results from a Multi-Country Study hased on Cointegration and Error-Correction Modeling Techniques* Energy Economics 18. 165 183.

Masih. A.M.. M. Masih. R. (1998). .-1 *Multivariate Cointegrated Modeling Approach in Testing Tem/x>rat Causality between Electricity Consumption. Real Income and Prices with an Application to two Asian LDCs.* Applied Economics 30. 1287-1298

Moritomo. R.. Hope. C. (2004). *The Impact of Electricity Supply on Economic Growth in Sri Dmka* Energy Economics 26. 77 85.

Mureithi 1.1». Kimuyu P.K & Ikiara P.K (1982) *The Effects of Higher Energy Cost on the Balance of Payments, Employment. Technological Choice and Real Incomes in Kenya.* ILO Working Paper in World Employment Programme. Geneva: ILO

Mwega F.M and Ndung'u S.N (2002). *Explaining African Economic Growth Performance The Case of Kenya* ALRC Research Paper No.82. Nairobi; Al RC.

Nurayan, P.K.. Smy th. R. (2005). *Electricity Consumption, Employment and Real Income in Australia Evidence from Multivariate Granger Causality Tests.* Energy Policy 33.1109 1116.

Nganga. Munyu. (2005) personal communications at the Ministry of Energy..

Nganga M.. (1990) *ITw impact of Rural Electrification on Rural Households*: A case of Kiambu district. University of Nairobi. Unpublished MA Ihcsis.

Nyoike, P. M. (2003). *Impacts of Power Sector Reforms on Private Investment ami Poor, final report,* Nairobi; Al REPREN

Onjala. J. (1992) *Energy-Economy Interactions in Kenya,* unpublished MA Thesis. University of Nairobi

Phillips. P.. Perron. P. (1988). *Testing for a I nil Root in Time Series Regression.* Biometrika 75. 335 - 346.

Republic of Kenya (1986). *Sessional Paper So. / of 1986 an Economic Management for Re/tewed Growth.* Nairobi: Government Printer.

Republic of Kenya (1997) *Electricity Power Ad.* Nairobi; Government Printer.

Republic of Kenya (2003) *Energy Sector Dewlopment Strategy,* Rural Energy I ask l orcc Final Report, Nairobi: Ministry of Energy.

Republic of Kenya (2004): *Investment Programme for the Economic Recovery Strategy for Health and Employment Creation 2003-2007*, Nairobi: Government Printer

Republic of Kenya (various issues) *Economic* .Survey. Ministry of Planning and National Development. Nairobi: Government Printer.

Scnga. W.M.. W.J. I louse & M. Manundu (1980). *Assessment of Commercial Energy Supply << Demand in Kenya. 1936-19$3.* IDS Report No. 3. University of Nairobi.

Shiu. A.. Lam. I..P. (2(MM) *Electricity Consumption and Economic Growth in (hina.* Energy Policy 30. 47 54.

Slern. D.I. (19930. *Electricity Use ami Economic Growth in the USA A Multivariate Approach. Energy Economics* 15. 137 - 150.

Stem. D.I. (2000). *A Multivariate Cointegration Analysis of the Hole of Electricity in the US Macroeconomy. Energy Economics 22. 2t>~ 2SJ.*

UNDP (1997). *Energy after Rio: Prospects and Challenges.* New York: UNIX'

UNEP and Climate Network Africa (CNA) (2004). *Energy in the East African Community.* Nairobi: CNA.

Wolde-Rufacl. Y (2004). *Disaggregated Industrial Energy Consumption and GDP Hie Case of Shanghai. 1952-1999.* Energy Ecoromics 26.69 - 75.

World Bank and UNDP (1982). *Kenya; Issues and Options in the Energy Sector.* Washington DC: World Bank

World Bank (2000) *Rural Energy and Development.* Washington DC: World Bank.

Yang. II.Y. (20(H)). *A Note on the Causal Relationship between Electricity and GDP in Taiwan.* I ncrgy Economics 22. 309 317.

Yoo. S II (2005). *Electricity Consumption and Economic Growth Evidence from Korea.* Fnergy Policy 33. 1627-1632.

Yu. E.S.M., Choi. J Y (1985). *The Causal Relationship between Electricity ami GXP An International Comparison.* Journal of Energy and Development 10. 249-272.

APPENDIXII

Data

I able A1: Raw Data

Poriod	Nominal GDP (million KES)	Electricity Consumption (million KWh)
1970	11454	645 8
1971	12702	715 2
1972	14448	794 8
1973	16560	859 7
1974	20342	978 9
1975	23344	1136 1
1976	28993 2	1152
1977	37083 6	1273
1978	40996 2	1371
1979	45437	1479
1980	52649	1538
1981	60771.6	1663
1982	708744	1701
1983	792334	1747
1984	88826 2	1845
1985	99865 6	2014
1986	116863 8	2158
1987	131216	2372
1988	151194 2	2407
1989	171588 8	2488
1990	195536 4	2665
1991	221249 8	2778
1992	256142	2830
1993	320150 6	2970
1994	393690	3067
1995	480805	2264
1996	5287395	3339
1997	623235 1	3527
1998	690910	3447
1999	742135 7	3534
2000	967838	3197
2001	1025918	3362
2002	1038764	3608
2003	1141780	3758
2004	1273716	4080

fable A2: Refined data

Porlod	Roal GDP (million KES)	Electricity Consumption (million KWh)
1970	9702	645 8
1971	10248	715 2
1972	13172	794 8
1973	13810	859 7
1974	14382	978 9
1975	249622	1136 1
1976	25562	1152
1977	278052	1273
1978	29658 8	1371
1979	30894 8	1479
1980	31640 4	1538
1981	318132	1663
1982	60987 4	1701
1983	62529 4	1747
1984	63057 1	1845
1985	66289 6	2014
1986	69963 8	2158
1987	73368 8	2372
1988	771394	2407
1989	81061 9	2488
1990	844726	2665
1991	86229 8	2778
1992	86644 3	2830
1993	86855 8	2970
1994	89491 5	3067
1995	93802 6	2264
1996	98151 8	3339
1997	100472 8	3527
1998	102252 7	3447
1999	103701.5	3534
2000	103455.7	3197
2001	104731 2	3362
2002	105944 5	3608
2003	107800 5	3758
2004	110659.3	4080

APPENDIX II

Tables

1 able A3: Percentage Sectoral Contribution lo GPP

Scctor	2000	2001	2002	2003	2004
Agriculture. forestry and fishing	29.1	27.6	25.5	25.1	24.2
Mining & quarrv ing	0.4	0.5	0.5	0.5	0.5
Manufacturing	10.3	9.7	9.8	9.6	9.9
Llectricin and water supply	1.9	19	•>	2.1	1.8
Building and construction	2.8	3.1	3.1	3.2	1.6
Wholesale and retail trade	9	9.1	9	9.1	10.1
1 lotel and restaurants	1.2	1.2	1.2	0.9	1.1
Transport and communication	8.9	9.6	10.1	9.9	10.3
financial intermediation	3.5	4.1	3.6	4.3	3-8
Real estate, renting and business services	5.5	5.7	6	5.9	5.7
Public administration and defense	1.6	4.6	4.4	4.4	4.5
bducaiion	5.9	6.1	7.3	7.9	7.8
1 lealth and social work	2.1	2.3	2.6	2.6	2.5
Oihcr community, social ami personal services	·	▪	4.2	3.9	3.1
Private households	0.4	0.4	0.4	0.4	0.4
Less: financial services indirectly measured	-0.9	•1.1	•0.9	-0.9	-0.7

Source Republic of Kenya (2005) Economic Survey

Table A4 : Per capita CiPP relative lo per capita commercial energy consumption for selec countries,

COUNTRY	Per Capita (Irons National Income (1JS S/CAPITA)		Compound Growth Rate %	Per Capita Commercial Energy Consumption (koe/capita)		Compound Growth Ka«c %
	1971	2lKX)		1971	2000	
Kenya	127	350	3.6	116	X9.4	•<0.9)
Tgypt	211	1,490	7.0	213	726	4.3
South Africa	710	2.600	4.5	1.993	2,514	0 8
Zimbabwe	264	440	1 8	443	800	2 1
Malaysia	406	3.380	7.6	435	2.126	5.6
South Korea	298	9.010	12.5	507	4.119	7.5
Singapore	1 1ItU 1 .Ooft	•>1 "7V<1 -oV	11 i 1 1.1	i<<i 1 . S s I	A i in n. I JO	1 V
Sub-Saharan Africa	198	476	3.1	225	517	2.9
High Income hconomics	3.066	27.608	7.9	4.407	5.694	0.9

Source WorM *Rank, IFoHaPevfio/imetU Int/kulm•% ivartom i.wues)*

Table A5: Empirical results from causality tests for .Asian countries

(ountrv	Empirical »ori	Stud> period	Causal rvlnliomhip I method u««d)
China	Shiunml 1 nm (200-t)	1971 20IXI	1 nety)-income (cnor-cocrwitoni
India	Maul. and Masifa (1996)	1955 ivwi	f ncrjfy income (com-corrcction)
	•Vsalii-Adjavc (XIOO)	I97J-I995	1 nerps •income i crror-corrcction)
	<ihu>h(2002)	1950 1997	lacomc-ckctrkat) (umwrtnvted VAR)
Indonesia	Mtfih and M*ih< 19961	1960-1990	Incoinc-cnorps (error-corrcction)
	Awru-Adjayc 12000)	197J 1995	1 nerpwiwtiinc (cnor-tiirrettiun)
lafsui	F.ml aul Yu 119*71	1950 19*2	1 ntrjtywiconK island aid Gran perl
		1950-1973 1950-1974	Incoiiv-viwyn (standard (ii anger l
M,IIJ\MU	Makih iirvl Ma>ih(l996|	1955 1990	VMM-Colnicgratcd I criiit-uirrcctlon)
PiaLnlan	Mosih and M«%ih(l996)	1955-1990	InooffiC^nefyy (crrw-corrcction I
Itiilipjiinc*	Yu lll*I Choi <1985)	1954 1976	1 IWTgy-income l itaiwlanl I n.inpii i
	Mawh and Ma»ih(l996)	1955-1991	Non-eu wic grafed i error-cot reel ah i)
	Atafu- \d»»>e <20001	1971 1995	1 nergyfocome (enor-cortw lam)
Singapore	Ma»ih and M.»ih (i m i	I960 1990	Non-comic^raied (error-corrcctnm)
	filature and Lee (1997)	1961 1990	1 ncnp-incomc (ennr-u meet ton)
			Enetgyincome (sundard Graagct)
Smiili Korea	Yu and ChoH 19*5)	1954 1976	Income-energy i standard < irangcri
	Olwure and Lcc< 1997)	1961-1990	llncrgyfoainie (etrnr-vorreclkm)
			No relationship (standard (.ranger 1
Sn Lanka	Mash and Masih i 1998)	1955-1991	Energy-income terror-correction)
Taiwan	Huanp and (>uni 41992)	1961 IWI	1 ncrgy-incoou: itiian>yiand 1 l»uo)
	l hcnganJ Lai (1997)	1955-1993	Income-energy <1 Istao's Granger)
	Yang (2000)	1954 IWT	• neryy-income (ctuw-mmiiioni
1 II.III.UII5	M*»ih and Mailh(IVsiX)	1955-1991	Lnergy-uiciune (error-corrcaiool
	Asafu-Ad>»>c 42000)	1971 l<*<	Fnrrgy-income lcrrot-cotrvvl«ml

Source. .hum Inunult o) ftchmMogy. Ml}

APPENDIX III

Graphs

I inure A1. Trend inelectricity consumption

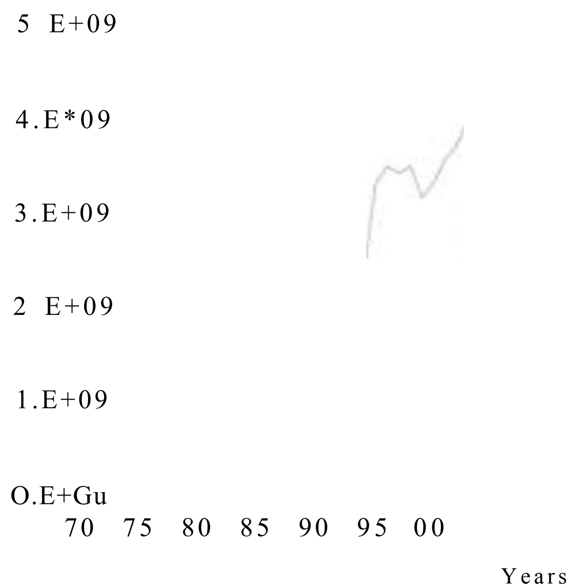
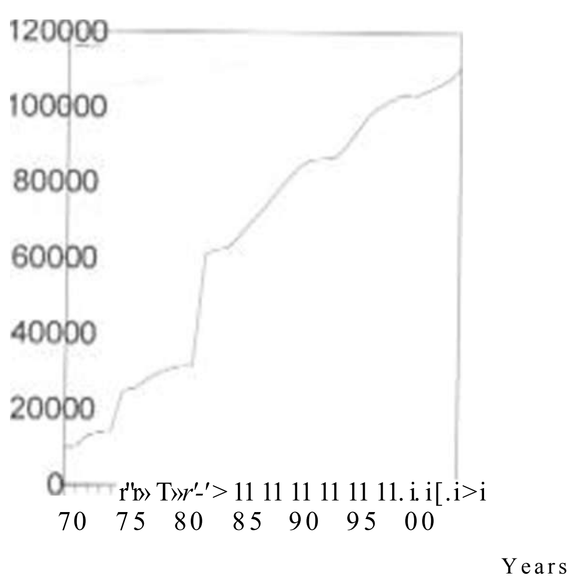
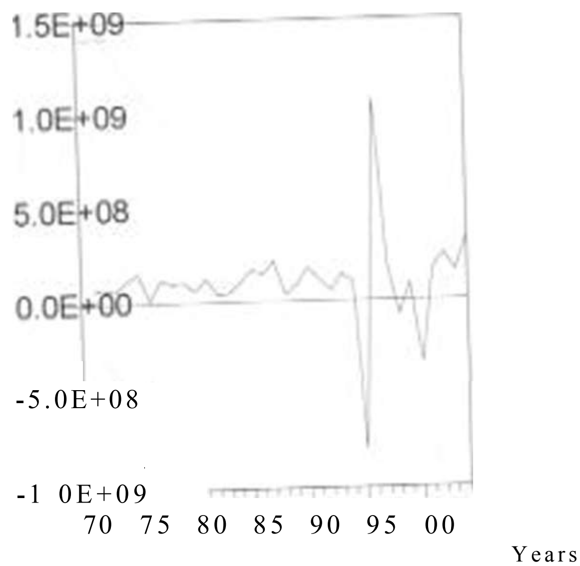


Figure Ail;TrwdjnGDP



t-i>.iir.- A3. I rci"* Ml- first diffcrcmv for clyytncitv yonsumpljon



FiK»»e A4: I ivml •'•"'•"••lee for CiDl'