EFFECT OF ENERGY CONSUMPTION ON ECONOMIC GROWTH IN KENYA

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DECLARATION

I, the undersigned, declare that this is my original work and that it has not been submitted to any other college, institution or university other than the University of Nairobi for academic credit.

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APPROVAL

This research paper has been submitted for examination with my approval as the designated supervisor.

Signed …………………………………. **Date**……………………………………..

DR. PATRICK MACHYO

SCHOOL OF ECONOMICS

DEDICATION

To my dear parents CHRISTOPHER W. SIFUNA and NANCY K. MASAFU.

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My gratitude to the Almighty God for the strength and favour in the academic life at the University of Nairobi.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADF	-	Augmented Dickey Fuller
ARDL	-	Autoregressive Distributed Lag
CES	-	Constant Elasticity of Substitution
CUSUMSQ	-	Cumulative Sum of Squares of Recursive Residuals
CUSUM	-	Cumulative Sum of Recursive Residual
EC-EG	-	Energy consumption economic growth link
GDP	-	Gross Domestic Product
KGOE	-	Kilogram of oil equivalent
KIPPRA	-	Kenya Institute for Public Policy Research and Analysis
KNBS	-	Kenya National Bureau of Statistics
LR/SR	-	Long Run/ Short Run
MOEP	-	Ministry of Energy and Petroleum
VECM	-	Vector Error Correction Model

ABSTRACT

This paper uses the ARDL Bounds technique to examine the relationship of incremental energy use on Kenyan economic growth as well as causality during the period of 1979-2014. Overall findings showed a LR relationship from capital, energy consumption and trade openness to growth existed. Energy is an important determinant of growth, both in the short run and long run. Causality patterns affirming this contribution as corroborated by the growth hypothesis findings.

CHAPTER ONE: INTRODUCTION

1.1 Introduction

The paper presents an empirical study of the effect of energy consumption on Kenya's economic growth for the period 1979 to 2014. It sought to provide econometric evidence of this effect as well as directional causality on the back of improved national accounts due to the rebasing done in 2014, with the assumption that this relationship is more profound for countries with higher incomes per capita.

This study focused on energy since it is one of the foundations of the Economic Pillar of the Vision 2030 (Government of Kenya, 2007) that targets a 10 percent per annum sustained growth by 2030; in the process determining whether the inclusion of energy in the growth model could explain the growth of the country other than just labour and capital as argued in most macroeconomic growth theories. The study was also undertaken because more focus is being made to improve the energy sector by exploiting alternative energy sources through increased investment in renewable energy in light of the environmental degradation and the need for energy security.

Similarly, Kenya undertook the rebasing of its national accounts in 2014, moving into the middle-income countries bracket. Could the rebasing of the national accounts therefore render energy consumption a better explanatory variable? Directional causality was undertaken with the expectation that resultant empirical country specific findings on Granger causality would contribute to the energy policy discourse in the country.

To achieve these objectives, the study incorporated energy consumption as an additional variable to the augmented production function of gross domestic product-dependent variable- with capital and trade openness as the other independent variables to minimize the omitted variable problem. Given that the variables in the model are on an upward growth trend, nonstationarity of the variables involved was taken into account. The ARDL model was used to determine the presence of co-integration among the variables given its advantages over other co-integration tests such as the Johansen test in its applicability to studies with small sample data such as the current study with 36 observations. For direction of variable relationship, the Granger causality procedure was applied.

1.2 Background of the Study

Energy is one of the foundations on which the Kenya Vision 2030 Pillars are anchored. It aims at generating more low-cost energy and increasing efficiency in energy consumption, (Government of Kenya, 2007). From the demand perspective, the general understanding is that a fall in electricity costs would be expected to coincide with a fall in consumer energy bills and subsequently a rise in electricity demand while from the supply side, lower bills would imply lower costs of production for the manufacturing and service industries translating into the expansion of supply and lower prices for inputs and consumer goods (KIPPRA, 2015).

Energy demand being derived demand is needed to provide a set of energy services and is necessary for continued economic activity in modern industrialized nations, (Hunt and Evans, 2009). It is therefore critical in the production process either as an intermediate or final input necessary for the transformation of raw materials into final goods and services. Keho (2016) argues that it supplements production along with capital and labour while Esen and Bayrak, (2017) conclude that a country's production level and its consequent degree of economic growth is influenced by not only other factor inputs but also complemented by energy.

An increasing national output and the associated creation of value is directly related with an increased energy use and the related improved capacity to pay for the energy (Zweifel, P., et al., 2017). Keho (2016), Chang and Li. (2015) and Wolde-Rufael (2009) argue that energy consumed in a country is directly related to the economy's growth stage, per capita income and economic liberalization. Kenya's economic structure is still dominated by the agricultural and manufacturing sectors as reflected in figure 1.1, sectors whose energy intensities are very high partly explaining the growth of per capita energy consumption. This structure is consistent with assertions by Hunt & Evans (2009), on the rise and the subsequent decline in units of energy per unit GDP as the economy's output composition changes.

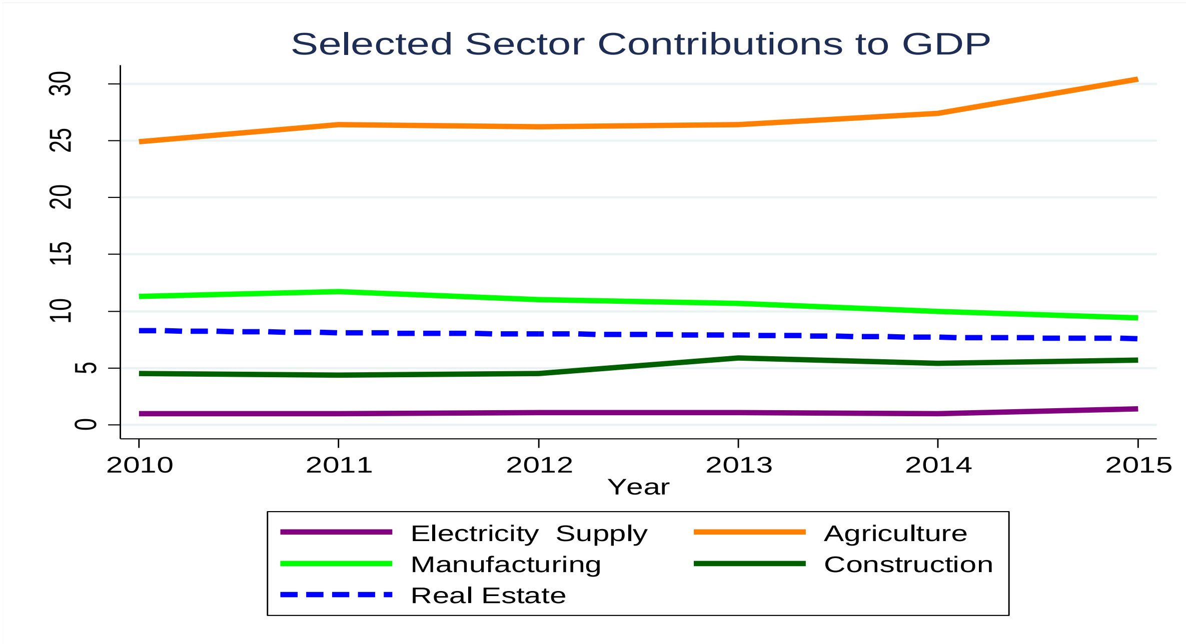


Figure 1.1: Selected Sector Contributions to GDP

To this extent, energy consumption is important in the social economic and environmental advancements of a country. An understanding of the energy-output causality relationship for the period 1979-2014 is therefore undertaken to strengthen policy directives in the energy sector.

1.2.1 The Energy Sector in Kenya

The Energy and Petroleum ministry coordinates this sector on policy as well as guidance on investment and development of the Petroleum, Electrical power, Renewable energy and Geothermal Exploration sub-sectors (MOEP, 2016).

The legal and regulatory set-up includes; first the Energy Policy as set out in the Sessional Policy Paper No. 4 of 2004. Second is the Energy Act, No. 12 of 2006 that among other rules and regulations establishes institutions for the regulation of the industry (MOEP, 2016). Regulations include the Renewable Energy regulations, the Petroleum Regulations and the Electricity Regulations; (MOEP, 2016) to strengthen the energy sector and supplement the Act. These legal and regulatory frameworks are in line with the Vision 2030 aimed at increased low-cost energy generating as well as increased efficiency in energy consumption.

1.2.2 Energy Consumption in Kenya

The Country's energy consumption is divided into biomass energy (69%), fossil fuels (22%) and electricity (9%), (MOEP, 2016).

Biomass is extensively used in rural areas (87%) and (82%) in the urban set up to provide energy with wood fuel contributing 68.7 percent and charcoal 13.3 percent of the over 80 percent of Kenyans using this energy source (MOEP, 2016). Alternatives such as biogas and solar energy need to be exploited given the adverse environmental impact of charcoal and firewood use and the subsequent supply constraints occasioned by Government regulations on deforestation and charcoal burning.

The Electricity Sector, a key driver of the commercial sector in Kenya, has seen continued expansion aimed at meeting electricity demand that has been occasioned by the intensification of rural electrification and the increased domestic, commercial and industrial consumption. Growth in electricity supply can be best explained by the increased investment as reflected in Installed Capacity growth, a Megawatt total of 1,412.2 in 2010 to 2,333.6 in 2015. Figure 1.2 below shows a breakdown from each source for hydro, thermal, geothermal, wind, solar and cogeneration electricity sources.

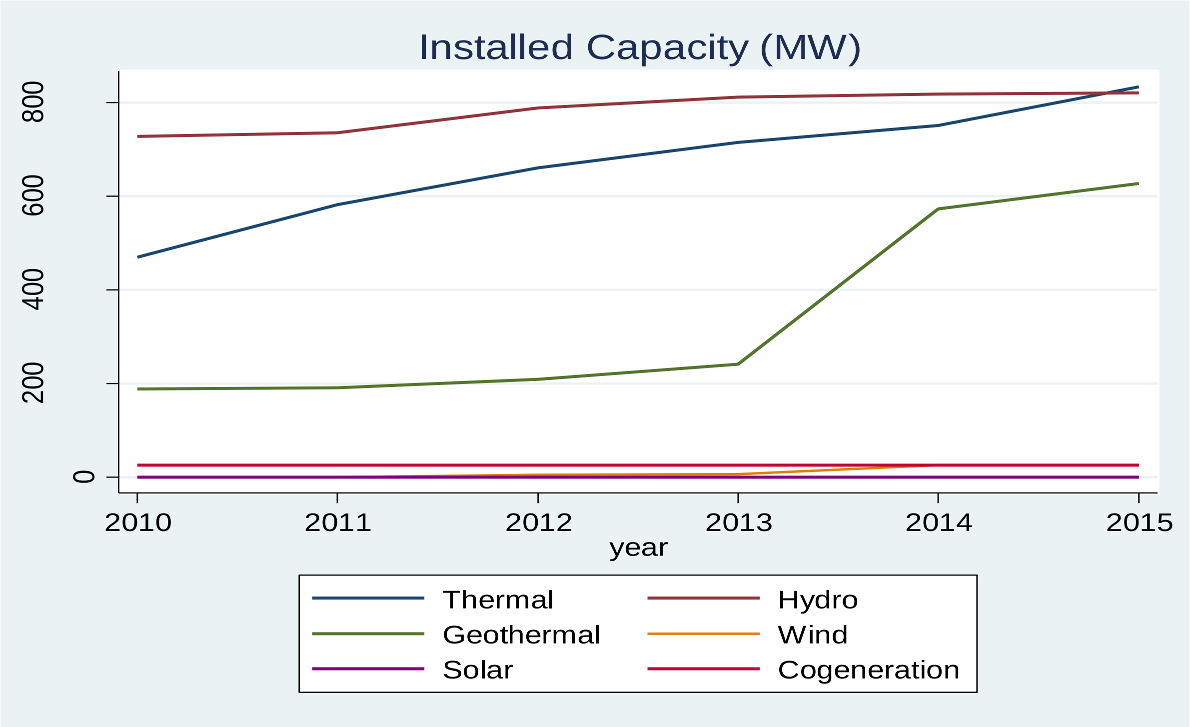


Figure 1.2: Installed Capacity (MW)

Geothermal energy sources showing the significant effects of increased capacity attributable to projects such as Olkaria IV and Olkaria I implemented in 2014 intended to increase the generation capacity to 140MW; a low cost investment intended to translate into a reduction in the cost of power due to its lower unit costs of production than thermal energy sources (KIPPRA, 2015) with statistics showing an increased Government's investment allocation in the fiscal year 2017/2018 to KSHS 16.4 billion to support the exploitation of geothermal, solar and wind resources in efforts to diversify the Country's energy mix (Republic of Kenya, 2017). This increase in installed capacity has translated into increased electricity generation from hydro and geothermal sources even though wind, cogeneration and solar energy generation still remain insignificant in the total electricity mix, (KNBS, 2017 Statistical Abstract).

The petroleum sub-sector in Kenya is predominantly that of exports and imports with this unlikely to change even with the continued Oil and Gas exploration activities in Turkana

(KIPPRA, 2015). Table 1.1 below shows the import and export of petroleum products, quantity and the related value for the selected 5-year period.

Table 1.1: Import and Export of Petroleum Products; Quantity and Value

	Quantity ('000 Tonnes)					**Value (KSH Billion)**				
	2011	**2012**	**2013**	**2014**	**2015**	**2011**	**2012**	**2013**	**2014**	**2015**
IMPORTS										
TOTAL	4,015	3,809	3,562	4,409	4,432	321.9	307.6	291.6	335.7	226.1
LOCAL EXPORTS										
TOTAL	125	56	29	55	31	7.8	3.8	2.1	5.54	6.2
RE-EXPORTS										
TOTAL	121	127	129	574	767	8.0	9.6	10.5	48.1	53.6
TOTAL EXPORTS	246	183	158	629	797	15.7	13.4	12.6	53.7	59.8
NET BALANCE						306.1	294.2	279	282.0	166.3

Source: KNBS; 2016, 2017, Economic Survey

Liquid fuels (imports of crude oil, imported petroleum and exports of petroleum fuels) are extensively used as a source of energy when compared to coal and coke as well as hydro and geothermal energy supply. Between 2011 and 2015, crude oil imports declined attributable to the closure of the Crude Oil refinery in the Country with this resulting in an increase in petroleum fuel imports. Given the international price fluctuations, the value of petroleum imports will keep fluctuating with fluctuations in these prices. The import bill manifested through the value of petroleum fuels also increased from 321.867 billion shillings to 335.671 billion shillings in 2014 and declined to 226.126 billion shillings in 2015; an observation that can also be made for the case of exports, (KNBS; 2016, 2017, Economic Survey).

The energy sector has therefore seen a consistent increase in developmental expenditure as evidenced through Government fiscal allocations. These efforts are aimed at ensuring energy security through strengthening the energy infrastructure given the sectors bearing on industry and transport sectors. Figure 1.3 below shows developmental allocations to the fuel and energy sector for the past 10 fiscal years. The fiscal allocation amounts have been converted to USD at the average 10-year conversion rate of USD/84.217 SHS.

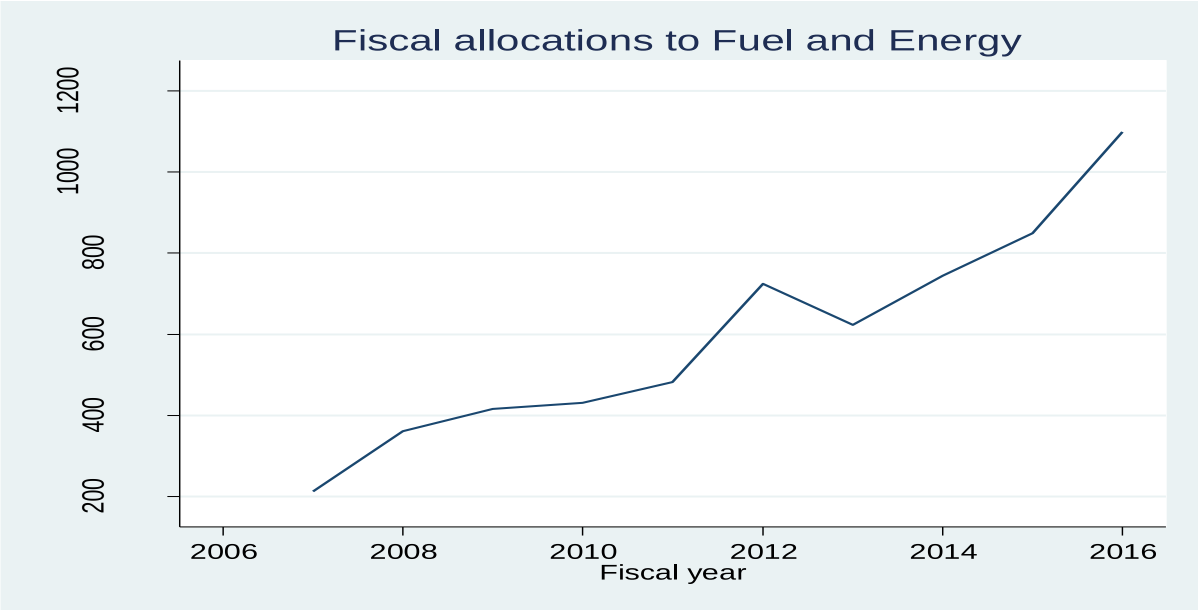


Figure 1.3: Fiscal allocations to Fuel and Energy

1.2.3. 2000-2014 Economic Growth-Energy Consumption Trend

Though declining from 5.7% in 2013 to 5.3% in 2014, Kenya's economic growth rate was influenced by increased government and private consumption as well as a robust fixed assets growth from the demand side and growth in agriculture, construction, wholesale and retail trade from the supply side (KNBS, 2015) increasing per capita output from 833 US $ in 2000 to 1076 US $ in 2014.

According to KNBS (2014), the rebasing of the national accounts in 2014 resulted in improved valuation and measurement of the country's output due to the incorporation of product changes resulting from research and development, improvements in the evaluation of the production structure as well as systemic changes in the relative prices of various products. This resulted in a 14.8% increase in GDP between the new and the old estimates in 2006 to 25.3% increase for the year 2013, surpassing the World Bank benchmark of USD 1,036 per capita, (KNBS, 2014). Figure 1.4 below shows energy use as well as the inflation adjusted GDP for a select 15-year period.

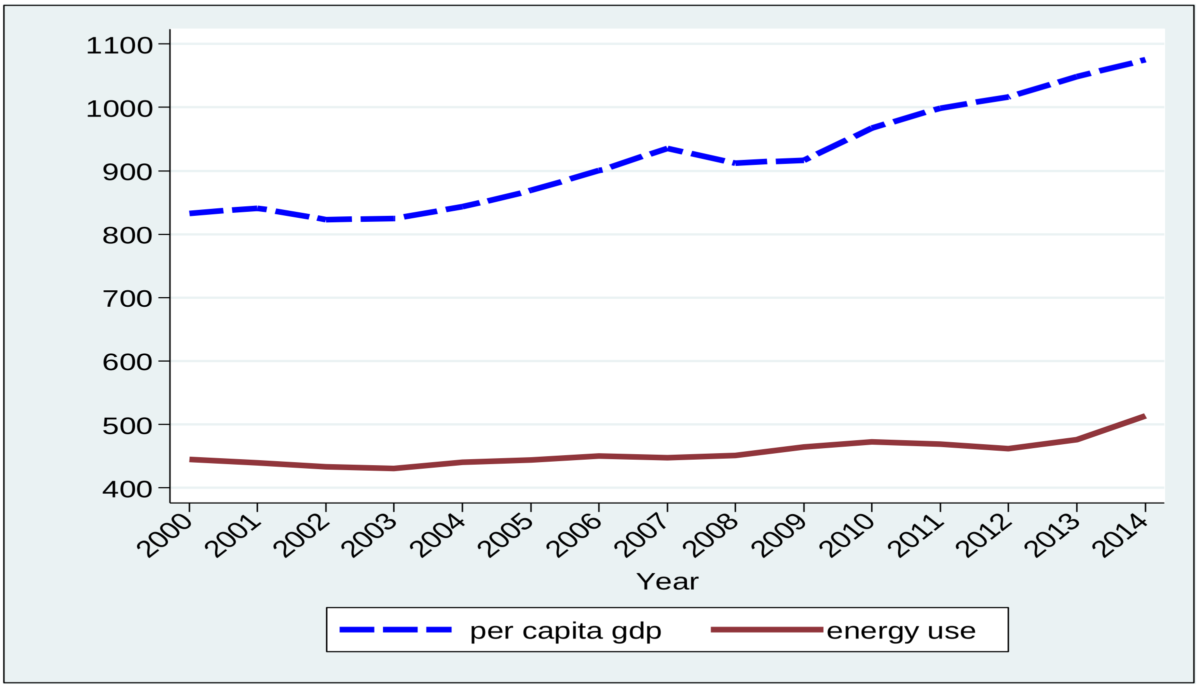


Figure 1.4: 15 Year Variable Trendlines

Energy consumption steadily increased over the course of the selected 15-year period from 445 in 2000 to 513 kilograms of oil equivalent per capita in 2014; with these changes attributed to institutional and technical changes in the energy sector aimed at increasing and diversifying the energy supply sources through the exploitation of geothermal power, coal and renewable energy as well as the continued exploration of oil and gas.

1.3 Statement of the Problem

Kenya's energy consumption per capita has been growing consistently, 445 in 2000 to 513 kilograms of oil equivalent per capita in 2014 and so has its output; 833 USD in 2000 to 1076 USD in 2014. Increased developmental expenditure/investment in the energy sector from 212.6 million dollars in the fiscal year 2007/2008 to 1098 million dollars in the fiscal year 2016/2017 has also resulted in the energy source diversification and the subsequent strengthening of the energy infrastructure. While the energy sector investments, energy consumption and efficiency are improving, the country's targeted annual growth of 10 percent as per the Vision 2030 has yet to be achieved.

The energy-economic growth studies indicate this relationship (effect as well as the direction of causality) to be more profound and better for countries with higher incomes than for countries with lower incomes (Keho, 2016; Chang and Li., 2015; Wolde-Rufael, 2009). Following the rebasing of the National accounts in 2014, Kenya moved into the middle- income countries bracket. Could energy consumption, therefore, better explain growth in gross domestic product? On the econometric methodology most studies on Kenya have majorly been in panel data study; with Kenya included among other countries in the study yet the effect and findings on directional causality have yielded varied results: Neutrality hypothesis-Wolde-Rufael (2009), Conservation hypothesis-Ozturk et al. (2010). With mixed findings also evident for studies by (Esen and Bayrak, 2017; Onuonga, 2012; Centitas, 2016; Chang and Li., 2015).

In this regard the current study extends the Energy consumption-Economic growth link literature in Kenya to a time series multivariate model by incorporating additional regressors in capital and trade openness, an improvement on the bivariate models by Onuonga (2012) that is also country specific and those by Esen and Bayrak (2017) and Ozturk, Aslan and Kalyoncu (2010) that are in panel model. In the process, the study determines the effect and direction of causality for the period 1979 to 2014 on the back of the improved national accounts as a result of the rebasing in 2014. According to theoretical assertions by Keho (2016), Chang and Li (2015) and Wolde-Rufael (2009), this relationship is better explained for countries with higher incomes per capita than those with lower incomes per capita.

1.4 Research Questions

i. What is the long run and short run relationship between energy consumption and economic growth?
ii. What is the direction of causality between energy consumption and economic growth?
iii. What policy recommendations can be drawn from the study?

1.5 Objectives of the Study

The main objective of the study is to ascertain the effect of increased energy consumption on the economic growth of the country both in the long term and short term.

Specific objectives are:

i. To ascertain the long run and short run relationship between energy consumption and economic growth.
ii. To analyze the directional causality of energy consumption and economic growth.
iii. To make policy recommendations grounded on the findings of the study.

1.6 Contribution of the Study

The study extends the country specific research on EC-EG to Kenya in a multivariate rather than bivariate framework by including trade openness and measures of capital on the understanding that growth is a factor of more than energy consumption. It provides an updated literature review in this area by incorporating natural resource growth model by Stern (2004) to the neoclassical models of Solow (1956) and Romer (1990) as well as literature on the long run energy demand as explained through the theory of dematerialization.

Econometrically, the study employs the ARDL Model in the analysis given its advantage in circumventing the small sample size problem while incorporating the Zivot-Andrews test in the unit root tests as an additional test for instances of structural breaks in the data.

Importantly, Energy sector stakeholders should benefit from this as they look to synchronize economic and environmental outcomes in harmony with the sustainable development goal 7-sustainable energy, 2030 UN agenda.

1.7 Organisation of the study

Following the introduction is chapter two which is the literature review. It provides both the theoretical and empirical literature that informs the study under consideration. Chapter three outlines the methodology adopted to achieve the study's objectives. Chapter four provides the analysis of the data, results obtained and a discussion of the same. Chapter five summarizes findings of the study, providing a conclusion and recommendations thereof as well as the weaknesses of this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In this chapter, the study reviews growth theories as well as empirical studies undertaken on this area by various scholars.

2.2 Theoretical Literature

2.2.1 The Solow Growth Model

According to Solow (1956), the rate of growth (Y) depends on the growth rate of capital stock (K)/savings, labour supply (L) and exogenously determined technological progress (A) and AL effective labour, with the technological progress so associated referred to as labour augmenting/Harold neutral.

$$Y(t) = K(t)^{\alpha}(A(t)L(t))^{1-\alpha} \text{ where } 0 < \alpha < 1 \quad (1)$$

According to Solow (1956), the assumption of the production function relates to capital and effective labour exhibiting constant returns to scale in output, but with declining marginal product of capital. From the former assumption incremental output (ΔY) due to an incremental K and L can be obtained as the sum of the products of marginal physical products of labour (MPL) and capital (MPK) with the respective increases in L and K, shown in equations 2 and 3.

$$\alpha \text{APK} = \frac{\partial Y_t}{\partial K_t} = \alpha K(t)^{\alpha-1}(A(t))^{1-\alpha} \quad (2)$$

$$(1-\alpha)\text{APL} = \frac{\partial Y_t}{\partial L_t} = (1-\alpha)K(t)^{\alpha}A(t)^{1-\alpha} \quad (3)$$

The latter assumption of decreasing returns in capital and labour in equations 4 and 5 below:

$$\frac{\partial MPK_t}{\partial K_t} = -\alpha(1-\alpha)\frac{Y_t}{K_t{}^{\wedge 2}} < 0 \quad (4)$$

$$\frac{\partial MPL_t}{\partial L_t} = -\alpha(1-a)\frac{Y_t}{L_t{^\wedge}2}<0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Solow (1956) acknowledges that savings, labour and depreciation are responsible for the accumulation of capital stock and the subsequent growth in output such that while higher rates of saving would increase transitory output, depreciation and population growth would act to restrain. The implication of this being a steady state level of the economy where savings would equal depreciation irrespective of the starting level of capital in the economy.

Solow (1956) therefore asserts that an increase in growth of the economy can only be brought about by technological progress, by continually shifting the production function and hence raising the effectiveness and productivity of labour. The shortcomings of the Solow model however are centred on its inability to explain origin and factors influencing technological progress. Additionally, the Solow model does not incorporate natural resources such as energy in growth.

2.2.2 The Endogenous Growth Model

In this model by Romer (1990), aggregate output is dependent on the quantities of capital, labour and technology which is treated as an endogenous factor, appearing in the production function as an input.

$$Y_t = \text{F}\ (K_t N_t A_t) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

According to Romer (1990), capital accumulation is actualised by technological knowledge acquired through research and development (R & D) and other knowledge creating processes. He argues that whereas intra-firm production exhibits constant returns to scale, there occurs external increasing returns to scale since benefits of technological improvements from research and development are not only limited to the undertaking firm but also other firms in the industry through copying the new methods and ways of doing things i.e. learning by watching.

Similarly, human capital investment results in not only an improvement in labour and capital productivity but also economy-wide worker productivity. In equation 7 where (e) is the direct labour input in production and H human capital, Romer (1990) models the technology coefficient A= H^{b} to represent the external effect of human capital (H) on productivity of capital (K) and labour (eL) so that while each firm faces constant returns to scale, the economy as a whole experiences increasing returns.

$$Y = AK^{a}(HeL)^{1-a} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Romer (1990) concludes therefore that technological growth works to offset diminishing returns to capital that inhibits growth so that the investment rate directly influences the growth rate. The Solow growth model as well as the endogenous growth model do not however describe the role of natural resources in growth.

2.2.3 The Growth Models with Natural Resources

Stern (2004) argues that economic growth can take alternative paths when natural resources-materials or endowments occurring in nature and which can be exploited for economic gain-other than just capital and labour are incorporated in the production process on the assumption of substitution and technological progress. He argues that technical conditions such as the ease of substitution among inputs and institutional arrangements determine sustainability possibilities (Stern, 2010).

In incorporating natural resources in the growth model Stern (2004) identifies elasticity of substitution (σ) between capital and natural resources to explain the interaction between the different inputs. While Stern (2004) identifies a unitary elasticity of substitution or perfect substitutability (σ=1); infinite substitutability (σ=infinity); elasticity of substitution greater than 1 and an elasticity of substitution of zero, (σ=0), he explains that for a given amount of positive inputs, output is bound to be positive only when (σ) is less than or equal to 1, a concept he refers to as the essentiality condition.

To model the growth models with resources, Stern (2010) incorporates the substitutability (low) concept between energy and capital and labour as well as the elasticity of substitution concept for capital and labour (unity), so that energy availability and the nature of technological change act to constrain or facilitate growth as modelled by the two equations below.

$$Y= \left[(1-\rho)\,(A_L^{\beta}\,L^{\beta}K^{1-\beta})^{\phi}+\rho(A_E\mathrm{E})^{\phi}\right]^{\frac{1}{\phi}} \quad (8)$$

$$\Delta K = s\,(Y - p_E\mathrm{E}) - \delta\mathrm{K} \quad (9)$$

The CES function in equation (8) incorporates the Cobb-Douglas function of the value added by capital (K) and labour (L) in addition to that by energy (E). In the equation, $\phi = \frac{\sigma-1}{\sigma}$ where σ is the elasticity of substitution between energy and the aggregate of the value-added. The parameters p_E and ρ are the price of energy, and energy-value added relative importance respectively while A_E *and* A_L are the augmenting indices of energy and labour. The equation of motion of capital (9), is similar with that under (Solow, 1956).

From equation 8 above, when σ->1 and ρ-> 0 we have the Solow as a special case, where the steady state, capital and output grow at the rate of labour augmenting. According to Stern (2010), when energy is in abundance, the savings rate, labour augmenting technology and rate of depreciation determine the balanced level of capital and output for a given elasticity of substitution, while the energy supply levels and the augmenting technology (A_E) will suffice when energy is relatively scarce.

2.2.4 Energy Demand in the Long Run

Developed by Bernardini and Galli, (1993) and used by Hunt and Evans (2009) to explain the energy demand and intensities in the long run, the theory of dematerialization postulates that units of energy per unit GDP initially increase then decreases with an increment in the GDP, as output of an economy grows.

Shifts in Output structure will result in changes in energy intensities, (Stern and Cleveland, 2004). Subject to the level of development and composition of industry in final output, different energy intensities will be required in the production process as the economy develops into a more service-oriented economy. This implies that for an economy characterised by a high proportion of the agricultural and industrial sectors, the energy intensity will be higher than later in the development stages of a country where the proportion of the service sectors is higher.

Regarding innovation and technology, technological improvements lower the energy requirements used in production, (Stern and Cleveland, 2004), while Esen and Bayrak (2017) argue that technical changes resulting in the reduction of energy consumed per output will increase energy efficiency in the production and consumption process (Hunt and Evans, 2009).

On the Substitution-complementarity relationship, Esen and Bayrak (2017) argue that in production, energy complements other factor inputs used to operate machinery and hence price increases in the short run result in costlier production and investment. Firms either reduce their production level due to increases in energy prices or to maintain a constant output level, use the same level of inputs and shift price increases to the final consumer. Over time, the energy increases necessitate the substitution (though subject to elasticity of substitution) for less energy intensive production structures.

Finally, energy quality and its composition in the energy input; where the energy requirements reduce on the instance of a firm using high quality energy with a corresponding higher marginal product, (Stern and Cleveland, 2004), an outcome that is achievable through increased consumption of renewable energy.

2.2.5 Causality Relationship between Energy and Economic Growth

Research on this relationship as investigated from the Granger Causality perspective has resulted into the four testable hypotheses following literature by Ozturk (2010).

Ozturk (2010) explains the Growth Hypothesis to be causal link from energy consumption to economic growth such that an increment/decrease in the former would have a direct and equivalent impact on the latter. Policy initiatives to increase energy consumption will translate into an increase in the output. Energy is hence a separate factor of production to aggregate capital and labour with different effects on economic output as influenced by technical progress such that shocks to energy supply would negatively affect growth. Where unforeseen energy shortages affect planned output, projects aimed at increasing energy supply (through the reduction of technical losses or incremental generation capacity) will allow output to increase without requiring the other aggregate factors of production to increase at the same time (Bacon and Kojima, 2016). Energy conservation efforts on the other hand through increased energy efficiency result in increased output through the reallocation of scarce resources to other production processes.

Ozturk (2010) explains the Conservation Hypothesis as one in which the link is from growth to increased energy use. This could be explained from the point of view that there is an improved capacity to pay and hence from a policy perspective, energy conservation may be inconsequential on growth, as evident in studies by (Cetintas, 2016; Ocal and Aslan, 2013).

For the Feedback Hypothesis Ozturk (2010) explains the link as mutual and would most likely imply that the two are interdependent, incremental-incremental as well as decremental-decremental association.

Ozturk (2010) explains the Neutrality Hypothesis as the absence of a causal link as is in the study by Wolde-Rufael (2009) in which the results specific to Kenya indicated. The weak and non-responsive observation being attributed to stages of development in the economy both in the energy and economy.

2.3 Empirical Literature

The empirical findings on the effect and directional causality vary as indicated in the theoretical literature review. This is irrespective of whether multiple county panel studies, country specific studies, bivariate studies, multi-variate studies or disaggregated energy studies (electricity, renewable energy) or sectorial studies are undertaken. This has been partly attributed to country specific energy heterogeneity as well as the different country development stages.

In multiple country panel, studies have not yielded conclusive deductions on directional causality despite econometric methodologies being advanced to account for country specific characteristics. Between 1971 and 2004 for a panel of 17 African countries, Wolde-Rufael, Y. (2009) found that the introduction of labour and capital to the model changed the results in thirteen of the prior investigated 2005 (paper) countries, strengthening the position that economic growth depended on the level to which energy, capital and labour complemented the growth process. For Kenya, the study found no relationship between these variables with the authors attributing this to low levels of energy efficiency. Importantly though was the fact that relative to labour and capital, energy was a more important factor in explaining innovations to economic growth in Zambia and Kenya.

These findings differ from the 1971-2005 bivariate panel study of 51 low- and middle-income countries by Ozturk, Aslan and Kalyoncu (2010). While the long-run findings supported the conservation hypothesis, the transitory findings showed a feedback relationship for these countries. Save for Kenya, Sudan and Ghana where an energy consumption increase caused gross domestic product increment, the overall panel context found a weak energy consumption to gross domestic product relationship, strengthening their position on energy sustentation.

In another panel study of 75 net energy importing countries between 1990-2015 by Esen and Bayrak (2017), with Kenya incorporated under both the lower-middle income economies bracket and also among countries whose level of energy dependence was below 50%, a strong positive L-R relationship existed, with the short run energy consumption coefficients though negative, significant, with the income levels further affecting this relationship. The writers also reinforced the argument that subject to the development stage, improved energy efficiency weakened the effect on economic growth arising from increased energy consumption.

In an investigation of the drivers of energy consumption, Keho (2016) found energy consumption to be co-integrated with real GDP per capita with the energy input variable used (per capita/total energy) affecting the sign and magnitude of the estimates. In the long-run, GDP and energy consumption per capita were positively related for all select countries with the exception of Benin while that position changed to a negative relationship for the case of Kenya when total energy consumption was used. Per capita GDP was an insignificant explanatory variable to per capita energy consumption but a significant explanatory variable to total energy consumption.

In a multivariate panel data framework for 11 Commonwealth Independent states from 1991 to 2005, Apergis and Payne (2009) found energy usage, capital and labour to positively affect real GDP with the inclusion of Russia only affecting real GDP responsiveness. This was an acknowledgment of Russia's strong macro-economic environment and development stage as well as its natural resource endowment. Their model results indicated a short-run unidirectional causality and long-run bi-directional causality from energy consumption to gross domestic product for both panels with and without the inclusion of Russia.

In a similar multivariate framework for 17 transition countries for the period 1992-2005 in which energy prices and employment as a proportion of population were included as additional variables, Cetintas (2016) confirmed a long run conservation hypothesis and a transitory mutual relationship for both panels with and without the inclusion of Russia, a divergent conclusion from that by (Apergis and Payne, 2009).

In China for the period 1990 to 2012, Wang et al., (2016) reveal a positive long-run co-integrating association between the variables while confirming the feedback hypothesis. This was further corroborated by the impulse response functions that indicated growth would be hindered by any reduction in energy consumption with Tang, et al. (2016) concluding that international exports were key for growth in China with any attempts to reduce the volume of embodied energy exports that are largely concentrated in the manufacturing sectors would translate into high direct and indirect trade costs on the economy.

In a 1981-2007 multivariate panel framework for 25 Organization for Economic Co-operation and Development Countries, Belke et al., (2011) found cointegration from the common factors (International perspective) but not for the idiosyncratic components. Strengthening the role of international developments such as changes in world market prices of oil in explaining energy demand and consumption patterns irrespective of the extent to which the countries were integrated and interconnected to the world markets with the directional causality revealing a bidirectional relationship.

In disaggregated energy studies in which the renewable energy perspective has been pursued, causality findings have not been different either. An insignificant impact, Ohlan (2016) for India between 1971 to 2012 with the short run growth hypothesis being confirmed. In a panel of 15 Asia-Pacific countries between 1994 and 2014, Liu et al., (2018) found a bidirectional long run causality and a short-run unidirectional causality. Varying findings are also evident in studies by (Apergis and Payne 2012; Alper and Oguz, 2016; Ocal and Aslan, 2013).

2.4 Overview of the Literature

While capital and effective labour are critical in growth (Solow, 1956; Romer, 1990) the incorporation of natural resources in the growth theory has become imperative. Studies by Stern (2004), Stern and Cleveland (2004) have improved on the neoclassical growth theories by incorporating natural resources through the essentiality condition while explaining the energy-growth link by augmenting energy (natural resource component) in the production function.

The energy-growth empirical literature on the other has shown that while the studies have been extensive, they still are inconclusive. While the methodologies have improved from bi-variate to multivariate models in order to tackle the omitted variables problem in both time series and panel studies, different country specific characteristics have contributed to divergent observations as evidenced in studies by (Apergis and Payne, 2009; Cetintas, 2016; Ohlan, 2016).

One clear observation however is the fact this link between energy and growth is better explained for countries with higher levels of economic performance and growth than those otherwise as asserted by (Wolde-Rufael, 2009; Chang and Li., 2015). The current study sought to undertake its research to confirm this position especially that in 2014 the rebasing of Kenya's national accounts moved the country into the middle-income countries bracket.

CHAPTER THREE: DATA AND METHODOLOGY

3.1 Introduction

This section discusses the theoretical framework and the model specification adopted by the study as well as giving the data source, measurement and variable description in the adopted model.

3.2 Theoretical Framework

The theoretical framework in this paper follows literature by Stern and Cleveland (2004), Stern (2010) on growth models that include resources; with energy input augmented in the production function, (equation 10). It is modelled along the Cobb-Douglas production function that acknowledges the essentiality condition as explained in the theoretical literature.

Y=F (K, O, E) …………………………………..…………….……………. …..……. (10)

Where per capita gdp (Y) is an expression of energy consumption (E), capital (K) all in per capita terms and trade openness (O) and expressed in equation (12) as:

$Y_t = A\, X_{1t}{}^{a1}\, X_{2t}{}^{a2}\, X_{3t}{}^{a3}$……………………………………..……………………..… (11)

Where (Y_t) is per capita gdp, (X_{1t}) capital, (X_{2t}) energy all in per capita terms and (X_{3t}) trade openness with a_i the factor shares with respect to each factor of production and A the total factor productivity.

All variables are converted to their natural logarithm forms (log-log linear form equation) to address non-linearity and seasonality of data as represented in equation (12).

$lngdp_t = \alpha_0 + \beta_1\, lncapital_t + \beta_2\, lneuse_t + \beta_3 lnopen_t + u_t$……………………….. (12)

Where the prefix ln is the logarithm of gdp $(lngdp_t)$, capital ($lncapital_t$), energy ($lneuse_t$) trade openness $(lnopen_t)$ with $\beta_i; i = 1,2,3$ the respective elasticities of the logs of capital, energy use and trade openness with u_t the error term. Energy and capital are expected to be positively related to national output consistent with findings by (Apergis and Payne, 2009; Wang et al., 2016) as is with trade openness in line with findings by (Sadorsky, 2012; Şahbudak and Şahin, 2016; Liu et al., 2017).

3.3 Pre-Estimation Tests

3.3.1 Stationarity Tests

The variables integration order will be formally determined using the ADF and the Phillips-Perron (PP) methods, (Gujarati, 2004); conducted on the null of presence of a unit root with the hypothesis rejected when the calculated statistic value is greater than the critical value, hence the nonstationary of the variables. Additionally, the Zivot-Andrews test as advanced by Zivot and Andrews (1992) is incorporated for testing unit root presence against the break stationarity alternative with the hypothesis only rejected when the Zivot-Andrew test statistic value is less than the critical value.

3.4 Model Specification

3.4.1 The Autoregressive Distributed Lag Modelling Approach (ARDL)

The bounds testing methodology advanced by Pesaran and Shin (1998) and Pesaran et al., (2001) incorporates both *I (0)* and *I (1)* variables to investigate the long run and short run coefficients of the explanatory variables.

The ARDL model has three advantages: first is its use to regressors that are either *I (0)* or *I (1),* second advantage being its efficiency in small sample and finite studies and finally it's application of a single reduced form equation in the estimation of the long-run relationship within a context of system equation, (Pesaran and Shin, 1998; Pesaran et al., 2001).

Accordingly, a dynamic unrestricted error correction model (UECM) can be derived from the ARDL to integrate the short run dynamics with the long run equilibrium, (equations 13 and 14).

$$\Delta lngdp_t = a_1 + \sum_{i=1}^{p} \beta_i \, \Delta lngdp_{t-i} + \sum_{j=0}^{q} \beta_j \, \Delta lncapital_{t-j} + \sum_{k=0}^{r} \beta_k \, \Delta lneuse_{t-k} + \sum_{l=0}^{s} \beta_l \, \Delta lnopen_{t-l} + \beta_{gdp} \, \Delta lngdp_{t-1} + \beta_{capital} \, \Delta lncapital_{t-1} + \beta_{euse} \, \Delta lneuse_{t-1} + \beta_{open} \, \Delta lnopen_{t-1} + \varepsilon_{1t} \quad (13)$$

$$\Delta lneuse_t = a_3 + \sum_{i=1}^{p} \beta_i \, \Delta lngdp_{t-i} + \sum_{j=0}^{q} \beta_j \, \Delta lncapital_{t-j} + \sum_{k=0}^{r} \beta_k \, \Delta lneuse_{t-k} + \sum_{l=0}^{s} \beta_l \, \Delta lnopen_{t-l} + \beta_{gdp} \, \Delta lngdp_{t-1} + \beta_{capital} \, \Delta lncapital_{t-1} + \beta_{euse} \, \Delta lneuse_{t-1} + \beta_{open} \, \Delta lnopen_{t-1} + \varepsilon_{3t} \quad (14)$$

Where Δ is the first difference Operator and ε_{it} are error term or disturbances.

Given equations (13 and 14) above, the bounds procedure, using either the Standard Walt test or the F-statistic can be used to test for cointegration under the null hypothesis that no co-integration vector exists (i.e.**,**$\beta_{gdp} = \beta_{capital} = \beta_{euse} = \beta_{open} = 0$**)** against the alternative hypothesis (i.e., $\beta_{gdp} \neq \beta_{capital} \neq \beta_{euse} \neq \beta_{open} \neq 0$).

According to Pesaran et al., (2001), where the calculated F-statistic is higher than the upper bound of the critical values, the null hypothesis can be rejected hence supporting the co-integration relationship; cannot be rejected if lower hence indicating no co-integration, and the deduction would be inconclusive if it falls in between the bounds, hence antecedent information on the variables integration order would be needed in decision making.

3.4.2 Granger Causality

If the ARDL bounds technique results on co-integration hold, the VECM obtained from equation (12) is estimated to determine the causal relationship as presented in a vector form:

$$\begin{pmatrix} \Delta lngdp_t \\ \Delta lncapital_t \\ \Delta lneuse_t \\ \Delta lnopen_t \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{pmatrix} + \sum_{i=1}^{p} \begin{Bmatrix} \beta_{11i} & \beta_{12i} & \beta_{13i} & \beta_{14i} \\ \beta_{21i} & \beta_{22i} & \beta_{23i} & \beta_{24i} \\ \beta_{31i} & \beta_{32i} & \beta_{33i} & \beta_{34i} \\ \beta_{41i} & \beta_{42i} & \beta_{43i} & \beta_{44i} \end{Bmatrix} \begin{pmatrix} \Delta lngdp_{t-1} \\ \Delta lncapital_{t-1} \\ \Delta lneuse_{t-1} \\ \Delta lnopen_{t-1} \end{pmatrix} +$$

$$+ \begin{pmatrix} \lambda_1 \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \end{pmatrix} ECM_{t-1} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (15)$$

Where (Δ), is as defined under equations (13) and (14), α_i is the constant term, ε_{it} are error terms with λ_i and ECM_{t-1} the error correction parameter and term respectively, where the latter should be significant statistically with its coefficient negative in sign. Determining the significance of the chi-square in the short run causality between the variables in the energy-growth equations in the matrix equation (15) will involve testing the null hypothesis of whether considered together, the coefficients of lagged independent variables, equal zero with the rejection of the null hypothesis indicating the presence of causal effects.

3.5 Data Source, Measurement and Description of Variables

The study uses the 1979 to 2014 data from the World Development Indicators Database for Kenya, (World Bank, 2018). Data limitations from the WDI for energy use which is the main variable under study guided the choice of time period. Similarly, data for periods prior to 1979 for gross fixed capital formation is unavailable from the WDI. The variables in the multivariate econometric framework are as shown in table 3.1 below.

Table 3.1: Data Source, measurement and description of variables

Variable	Description	Measurement Scale	Data Source	Expected sign
Dependent				
GDP	Total market value of all final goods and services annually produced in a country in constant 2010 U.S. dollars	**Ratio** Per capita GDP (PGDP) =GDP/POP.	WDI (2018)	+VE
Independent				
GFCF	Capital inclusive of land improvements, plant and machinery & equipment purchases in constant 2010 U.S. dollars.	**Ratio** Per capita GFCF =GFCF/POP.	WDI (2018)	+VE
EUSE	Energy use; use of all energy consolidated in natural resources such as coal, natural gas and renewable sources measured in kgoe per capita.	**Ratio** (Energy-use)/POP.	WDI (2018)	+VE
OPEN	Aggregate of exports and imports divided by GDP	**Ratio** (X+M)/GDP		+VE
Imports (M)	Total value of Inflows from without the country of all goods and other market services in constant 2010 U.S. dollars.		WDI (2018)	
EXPORTS (X)	Total value of outflows from within the country of all goods and other market services in constant 2010 U.S. dollars.		WDI (2018)	

Source: Own Tabulation

3.6 Justification of Variables Selected

The existing literature has modelled the impact and causal relationship in the energy growth nexus along the general production function equation. Energy has hence been incorporated as a separate input to complement the production process (Stern and Cleveland, 2004; Esen and Bayrak, 2017). Bacon and Kojima (2016) argue that in a production function relation, energy alone cannot explain economic growth hence the inclusion of labour and capital serves to minimize the omitted variables bias.

Gross capital formation positively impacts on energy consumption through the development of energy infrastructure. For segregated sectors, the renewable energy sector expansion for example positively impacts on the growth of capital formation which in turn directly impacts on output, (Apergis and Payne, 2009). Similarly, Chien and Hu (2008) conclude that infrastructure expansion efforts attributable to renewable energy add to capital formation through business expansion and hence economic development than efforts aimed at increasing tax on imported fossil fuels.

The inclusion of openness is premised on exports and imports being key in the energy sector such that to facilitate smooth production process, country specific deficits can be plugged through imports from energy surplus countries. Access to clean energy research and an upgrade on technology to enhance energy efficiency also requires the interplay of exports and imports. Kenya is also an importer of petroleum products and a significant percentage of the import bill that affects the economic growth is incurred so is the regional electricity trade through the East African Power Pool (EAPP) countries, (MOEP, 2016) as are findings by (Parsa and Sajjadi, 2017; Şahbudak and Şahin, 2016).

3.7 Diagnostic Tests

The study checks for serial correlation using the Breusch bgodfrey test, functional form using the Ramsey Reset test, normality using the Shapiro-wilk test and heteroscedasticity using the Breusch pagan test on the null hypothesis of no serial correlation, no omitted variables, normally distributed error terms and constant variance respectively, (Wooldridge, J. M. 2012). For stability of the coefficients, CUSUM and CUSUMSQ as investigated by Turner, P. (2010) were used.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter first outlines the empirical approach undertaken to quantify the interactions between the variables under study while presenting and interpreting the findings.

4.2 Descriptive Statistics

Table 4.1: Descriptive Results

Variable	N	Mean	P50	Min	Max	SD	CV	Skewness	Kurtosis
Per-capita GDP	36	894.6	876.9	823.1	1076	61.50	0.0688	1.368	4.370
Capital	36	122.2	98.55	77.28	242.4	45.77	0.374	1.221	3.264
Energy	36	451.8	448.2	430.5	513.4	15.74	0.0348	1.733	7.595
Open	36	0.405	0.407	0.263	0.578	0.0997	0.246	0.207	1.844

Source: Own computation using STATA

Table 4.1 indicates that per-capita gdp averaged $894.6 during the study periods (1979-2014) with the maximum of $1076 in 2014. This was attributed to a persistent and expansive growth in private consumption occasioned by a vibrant growth in the real estate sector as well as mega infrastructure projects; a factor that also contributes to the maximum per capita gross fixed capital formation in 2014 of $242.4 (KNBS, 2014) with the minimum of $823.1 a result of poor state of infrastructure, low investment and the spill over effects of prior year poor performances (KNBS, 2005). This is well corroborated by the trend analysis (figure 4.1-4.4), illustrating that per capita gdp, capital and energy use had an uneven growth between 1979 and 2000 but gradually increased from the years 2000 to 2014.

Averaging 451.8kg of oil equivalent per capita, energy use (figure 8) ranged from a low of 430.5 in 2003 to a high of 513.4 in 2014 attributed mainly to an increase in local production of geothermal power (Economic Survey, 2015).

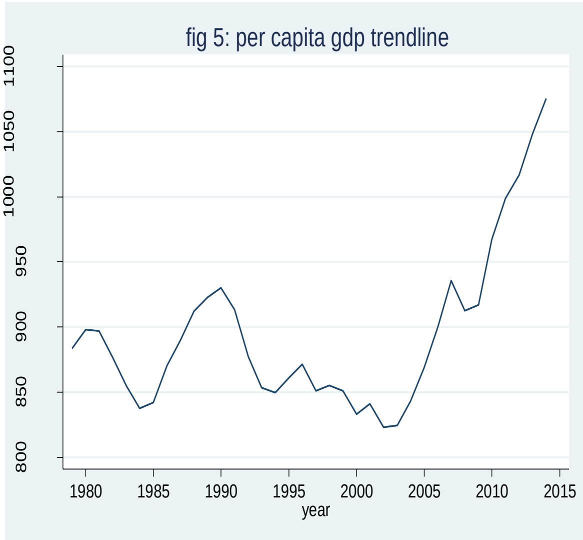


Figure 4.1: Per capita gdp trend line

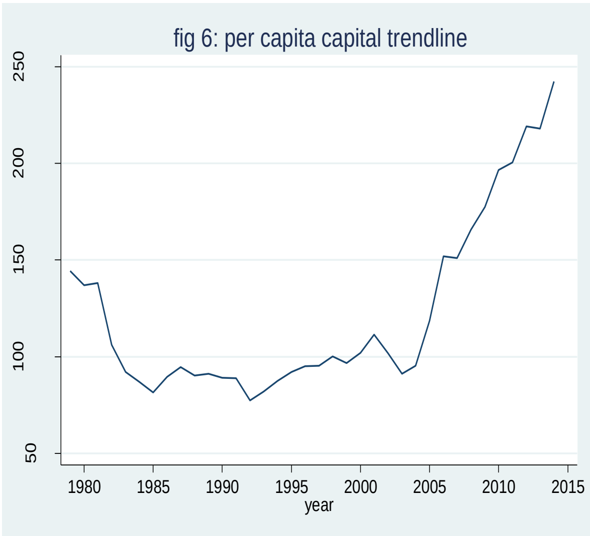


Figure 4.2: Per capita capital trend line

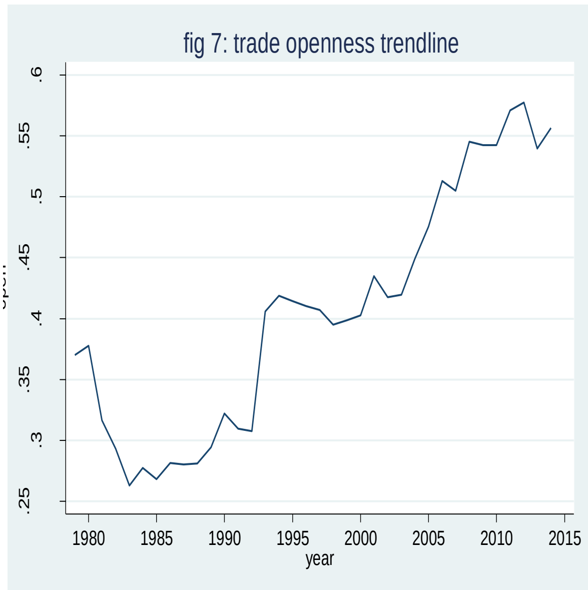


Figure 4.3: Trade openness trend line

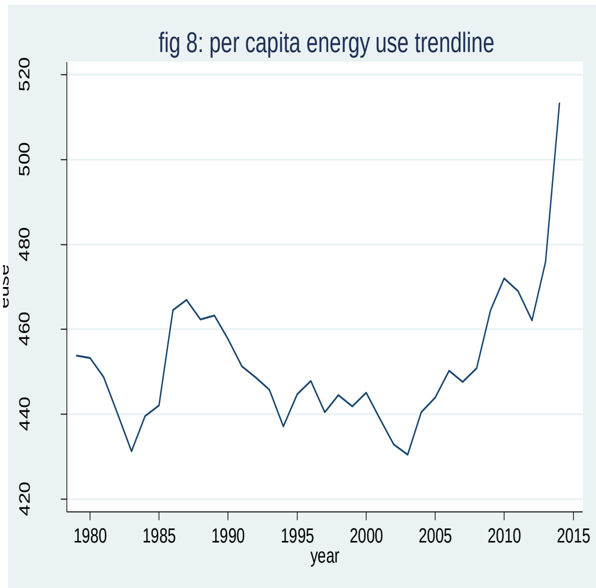


Figure 4.4: Per capita energy use trend line

The standard deviation of the variables from the mean is low indicating variable stability with the positive skewness implying extended right tails as graphically represented with the coefficients also within the normal distribution range of -2 to +2.

4.2.1 Correlation Analysis

Table 2.2: Correlation Analysis

	Lgdp	**Lcapital**	**Leuse**	**Lopen**
Lgdp	1			
Lcapital	0.8034*	1		
Leuse	0.8624*	0.6410*	1	
Lopen	0.4723*	0.7542*	0.3066	1

Key: Asterisk (*) indicates 5% level of significance

The correlation matrix indicates existence of high positive associations between energy and output indicating its high relative importance to the county. Gross fixed capital formation is also positively correlated to energy use and trade openness; consistent with Kenya's international trade scenario that's dominated by imports of capital goods and petroleum products whose import bill is substantial (Economic Survey, 2015).

4.2.2 Pre-Estimation Tests

4.2.2.1 Unit Root Tests

Table 4.3: Stationarity Test Results

		Variable	lgdp		lcapital		leuse		lopen	
		Restriction	Trend	notrend	trend	notrend	trend	notrend	trend	notrend
Level	ADF		-0.521	0	-2.67	-0.091	-0.597	-0.273	-4.758**	-0.37
	PP		-0.314	0.311	-1.784	0.059	-0.383	-0.06	-3.379	-0.332
	ZA	T. Statistic	-3.395		-3.941		-1.284		-4.259	
		Inference	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)	I(1)
Ist Δ	ADF		-3.832**	-3.192**	-4.841**	-3.892**	-3.414***	-3.022**	-5.413**	-5.245**
	PP		-3.859**	-3.324**	-4.841**	-3.892**	-3.414*	-3.022**	-5.413**	-5.245**
	ZA	T. Statistic	-4.820**		-5.205**		-3.974		-6.473**	
		Inference	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Source: Own Computation from STATA

From Table 4.3, all the variables have unit roots at level as we fail to reject the null hypothesis of unit root at either of the levels of significance but on differencing, these variables become stationary; a confirmation that all the variables were integrated of order one, *I (1)* hence co-integration can be determined upon maximum lag length determination; table 4.4 below.

Table 4.4: Lag Order Selection Criteria

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	153.931				1.0e-0.9	-9.37069	-9.30995	-9.18747
1	265.673	223.48	16	0.0000	2.5e-12*	-15.3546*	-15.0509*	-14.4385*
2	278.158	24.97	16	0.0700	3.30e-12	-15.1349	-14.5883	-13.4859
3	292.854	29.392	16	0.0210	4.20e-12	-15.0534	-14.2638	-12.6715
4	307.785	29.862	16	0.0190	5.90e-12	-14.9865	-13.9541	-11.8719

Source: Own Computation from STATA

An optimal lag of 1 as evidenced by the significance under the FPE, AIC, HQIC and SBIC selection criteria is to be preferred.

4.3 Empirical Results

The ARDL Bounds technique results are illustrated in table 4.5 below.

Table 4.5: Bounds testing

HO: No level relationship F 7.276
case 3 t -4.507

	90% level		95%level		1%		p-value	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F	2.986	4.163	3.67	5.011	5.323	7.047	0.002	0.008
T	-2.575	-3.466	-2.932	-3.875	-3.669	-4.709	0.001	0.014

Note: Critical values from Kripfganz and Schneider (2018)
Finite sample (3 variables, n=32, 1SR Coefficients)

Source: Own Computation from STATA

From Table 4.5, the F-statistic of the ARDL (2, 0, 0, 0) bounds test under the null hypothesis of ($\beta_{gdp} = \beta_{capital} = \beta_{euse} = \beta_{open} = 0$**)** depicts the computed F-statistic (7.276) to be higher than the upper bounds at 10%, 5% and 1% indicating the existence of a co-integrating relationship, consistent with findings by Ocal and Aslan (2013). With confirmation of the cointegrating relationship, the study estimates the long run effects as presented in table 4.6 below and in equation 16.

Table 4.6: Long Run Results

	(1) D.lgdp
LR	
L.lcapital	0.129*
	(2.35)
L.leuse	1.246**
	(3.67)
L.lopen	-0.0307
	(-0.53)
_cons	-0.559
	(-0.81)
N	32

Source: Own Computation from STATA

$lngdp_t = -0.559 + 0.129\ lncapital_t + 1.246\ lneuse_t - 0.0307 lnopen_t$………….. (16)

The estimated coefficients reveal not only a positive but also a significant impact at 5% for capital and energy consumption on economic output. Specifically, energy consumption has a positive magnitude of 1.246 implying that a 1% increment would precipitate a 1.246% economic upsurge. Similar findings by Ohlan (2016) with a magnitude of 2.25%, Sadorsky (2012) with a magnitude of 0.35% corroborating these findings. The implication of this high level of responsiveness indicating the high relative importance of energy on economic growth.

For gross fixed capital formation, the 0.129 magnitude implies that a 1% increment generates a 0.1294% incremental per capita gross domestic product. This means that gross fixed capital formation is a catalyst to sustain Kenya's economic growth corroborating the findings of (Chien and Hu, 2008). The results for trade openness are however negative and insignificant in this model.

Table 4.7: Short run results

	(1)
	D.lgdp
ADJ	
L.lgdp	-0.383***
	(-4.51)
SR	
LD.lgdp	0.289
	(2.04)
D.lcapital	0.0496*
	(2.15)
D.leuse	0.478**
	(3.45)
D.lopen	-0.0118
	(-0.52)
_cons	-0.559
	(-0.81)
N	32

Source: Own Computation from STATA

From the short run dynamics estimates in table 4.7 above and in equation 17, the lagged value of the adjustment(ECM_{t-1}) carries the correct and statistically meaningful sign at 5 per cent level of -0.383. The implication being that approximately 38.33% of the preceding year's disequilibrium in per capita output are corrected in succeeding period and it would take about 2.6 years to clear the whole disequilibrium. The statistically significant adjustment is further proof of a stable long run association and subsequently implying causality from energy, openness and gross fixed capital formation to economic growth.

$$lngdp_t = 0.0496\ lncapital_t + 0.478\ lneuse_t - 0.0118 lnopen_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (17)$$

For energy consumption, a positive and statistically meaningful effect of 0.478% on growth is observed, an indicator that it indeed is an important determinant of economic growth in Kenya as is capital whose positive magnitude of 0.0496 implies that a 1% increment would generate a 0.0496% increment in per capita gross domestic product; corroborating the correlation analysis and hence the significance of investment to the country.

A negative and statistically insignificant relationship for trade openness is however observed in the short run in this model. This could be attributable to the fact that while the volume and value of trade has been on the increase, the impact of the high import value on the balance of trade has negatively impacted the gross domestic product.

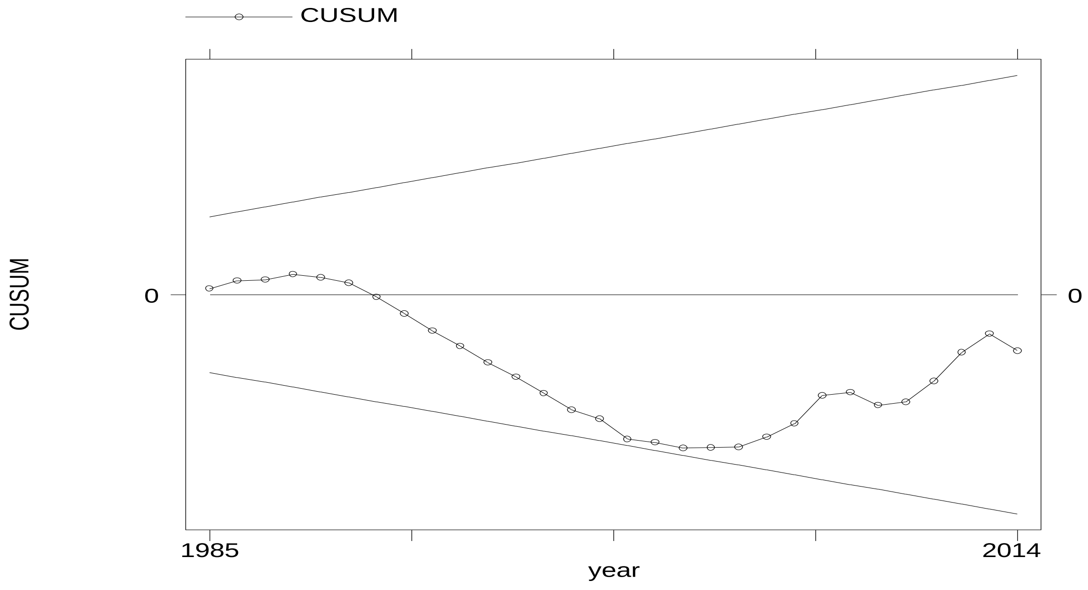
The post estimation diagnostics results are shown in table 4.8 below.

Table 4.8: Post Estimation Diagnostics

Post estimation Diagnostics		
Test	test-statistic	P-value
Normality	1.005	0.1574
Model Specification	1.120	0.3596
Heteroscedasticity	0.410	0.5199
Serial Correlation	0.481	0.4879

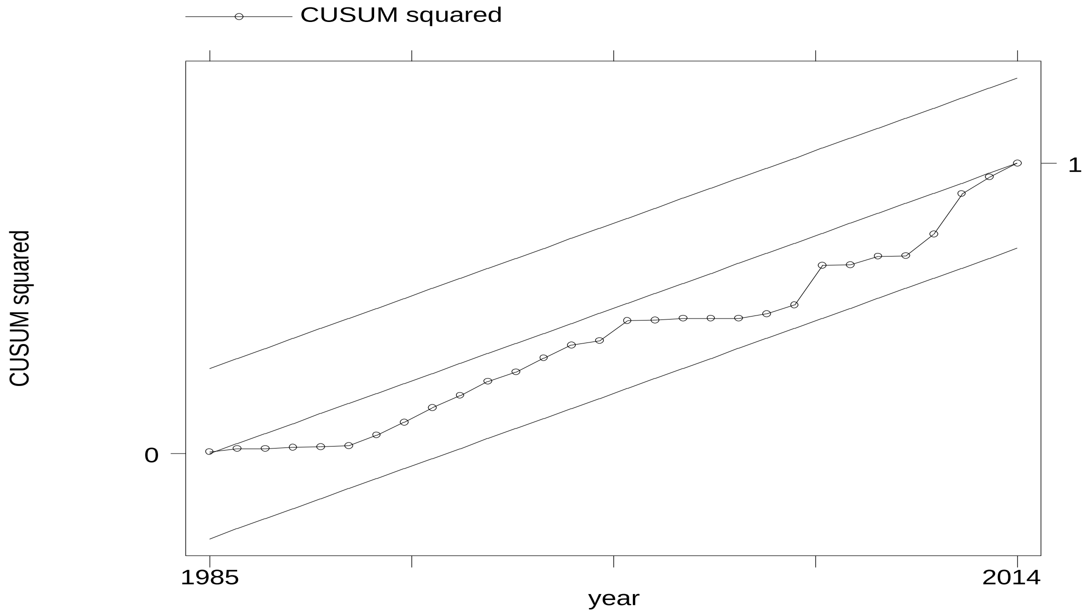
Source: Own Computation from STATA

The residuals of the model are not only uncorrelated across time but have constant variance and are normally distributed as we failed to reject the null hypothesis of these tests respectively while the Ramsey Reset test validates the functional form of the model to be well specified. Tests of parameter stability are as illustrated in figure 4.5 and 4.6 respectively, all depicting plots that are within the critical bounds hence a proof of long run model coefficient stability.



Source: Own Computation from STATA

Figure 4.5: Plot of CUSUM



Source: Own Computation from STATA

Figure 4.6: Plot of CUSUMSQ

Granger Causality

Given a long run relationship between the variables, there exists a causal relationship hence VECM Granger causality technique as determined in the table 4.9.

Table 4.9: Granger causality

Granger	causality	Wald	Tests	
Equation	Excluded	chi2	Df	Prob>chi2
Lgdp	lcapital	1.888	1	0.169
Lgdp	leuse	12.96	1	0
Lgdp	lopen	2.317	1	0.128
Lgdp	ALL	21.53	3	0
Lcapital	lgdp	0.106	1	0.745
Lcapital	leuse	3.313	1	0.0690
Lcapital	lopen	21.95	1	0
Lcapital	ALL	22.86	3	0
Leuse	lgdp	1.757	1	0.185
Leuse	lcapital	0.0299	1	0.863
Leuse	lopen	0.0579	1	0.810
Leuse	ALL	4.804	3	0.187
Lopen	lgdp	0.410	1	0.522
Lopen	lcapital	6.079	1	0.0140
Lopen	leuse	0.392	1	0.531
Lopen	ALL	6.685	3	0.0830

Source: Own Computation from STATA

With the exception of energy use, the null hypothesis that LCAPITAL and LOPEN do not granger cause LGDP cannot be rejected at 5% level of significance. Notably, all the variables under consideration explain growth in output (LGDP).

Conversely, the null hypothesis that LGDP does not granger-cause leuse is not rejected, drawing the conclusion of a causal connection moving from Energy use to GDP hence the Growth hypothesis deduction, results supported by (Wanjiku, 2011; Odhiambo, 2010), but a contrast to findings by (Onuonga, 2012).

CHAPTER FIVE: CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction

This chapter incorporates a summary of the study findings while advancing the main conclusions as drawn from the results.

5.2 Summary of Findings

The paper was aimed at determining the relationship and causality between energy consumption and economic growth based on the assertion that the relationship between them was more profound for higher income per capita countries than those without and more specifically for the Kenyan economy given the improved national accounts statistics occasioned by the rebasing in 2014.

To achieve the study's objectives, the stationarity properties of the variables was determined with all the variables found to be non-stationary at levels and stationary on first differencing. Additionally, the ZA test endogenously identified the break points in the variables under study with that for gross domestic product (2009), consistent with the new base year from the rebasing of the national statistics.

The ARDL Bounds technique used in determining co-integration found the existence of a long run relationship from trade openness, gross fixed capital formation and energy consumption to gross domestic product with a positive and significant relationship for the latter two variables with the exception of trade openness that revealed not only a negative but trivial relationship.

The short run estimates indicated a positive and statistically meaningful relationship for energy consumption and gross fixed capital with economic growth respectively although that for trade openness was negative and insignificant as well as a negative and relevant error correction term.

To analyse directional causality, the Granger causality test was used with results indicating a unidirectional causal link from energy consumption to economic growth supporting the growth hypothesis.

5.3 Conclusions

Through the research findings, the study concludes that energy consumption other than just labour and capital as argued in most macroeconomic growth theories indeed is an important factor of production, positively contributing to the growth of gdp both in the short run and in the long run. The growth hypothesis deduction is in line with findings by (Odhiambo, 2010) is supported from directional causality findings.

Neutrality findings by (Wolde-Rufael, 2009) for the case of Kenya that were attributed to low levels of energy efficiency and economic liberalisation indeed reaffirm assertions by (Keho, 2016; Chang and Li., 2015). The rebasing of the national accounts in 2014 that moved the country into the middle-income countries bracket (KNBS, 2014) indeed could have contributed to a better interaction between these two variables owing to improved valuation and measurement of the country's output and so are the institutional and regulatory frameworks within the energy sector.

5.4 Policy Implications

From the research findings, energy consumption is a driver of economic growth in Kenya hence its availability and reliability are key to the continuation of production.

To drive increased consumption, policy directives should be aimed at conducive pricing of commercial energy sources for the manufacturing/industrial sector given the expected multiplier effect on the cost of inputs and the subsequent pricing of final goods and services since from the findings increased energy use positively effects economic growth.

The growth hypothesis deduction implies that policy directives should be aimed at upscaling the energy infrastructure either through increasing the generation capacity or increasing efficiency by reducing technical losses that result in power outages. While this would not only add to the capital stock-since from the granger causality table, energy use granger causes gross fixed capital formation-the national output is also bound to grow.

Increased energy consumption results in the depletion of fossil fuel sources, which form a high percentage of consumption (69% and 22% for biomass energy and fossil fuels respectively). Policy directives should be aimed at diversifying the energy sources to renewable sources given the exhaustibility attribute of fossil fuel sources (oil, petroleum and biomass) and its susceptibility to price shocks that has an effect on the country's balance of trade.

5.5 Areas for Future Research

The study's weakness is that it does not disaggregate the energy use data between renewable energy and fossil fuel energy and neither has it disaggregated the data between commercial and non-commercial energy use for purposes of specific tailored policy directives for the study period of 1979 to 2014, partly attributable to the insufficiency of this data for periods prior to 1990 for the case of renewable energy from the WDI indicators. Subsequent research needs to look at the renewable energy aspect for specific tailored policy directives in this area.

REFERENCES

Alper, A., & Oguz, O. (2016). The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. *Renewable and Sustainable Energy Reviews*, *60*, 953-959.

Apergis, N., & Payne, J. E. (2009). Energy consumption and economic growth: evidence from the Commonwealth of Independent States. *Energy Economics*, *31*(5), 641-647.

Apergis, N., & Payne, J. E. (2012). The electricity consumption-growth nexus: renewable versus non-renewable electricity in Central America. *Energy Sources, Part B: Economics, Planning, and Policy*, *7*(4), 423-431.

Bacon, R., & Kojima, M. (2016). Energy, economic growth, and poverty reduction: a literature review. *World Bank, Washington, DC*.

Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: New insights into the co-integration relationship. *Energy Economics*, *33*(5), 782-789.

Bernardini, O., & Galli, R. (1993). Dematerialization: long-term trends in the intensity of use of materials and energy. *Futures*, *25*(4), 431-448.

Çetintaş, H. (2016). Energy consumption and economic growth: The case of transition economies. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(3), 267-273.

Chang, Y., & Li, Y. (2015). The Revealed Relationships between Energy Consumption and Economic Growth: Causality, Macroeconomics, New Trend, and Implications. *Handbook of Clean Energy Systems*, 1-16.

Chien, T., & Hu, J. L. (2008). Renewable energy: An efficient mechanism to improve GDP. *Energy Policy*, *36*(8), 3045-3052.

Esen, Ö. & Bayrak, M. (2017). Does more energy consumption support economic growth in net energy-importing countries? *Journal of Economics, Finance and Administrative Science*, *22*(42), 75-98.

Government of Kenya (2007). *Kenya Vision 2030: The Popular Version*. Nairobi: Ministry of Planning and National Development.

Gujarati, D. (2004). Basic Econometrics. United States Military Academy, West Point.

Hunt, L. C., & Evans, J. (Eds.). (2011). *International handbook on the economics of energy*. Edward Elgar Publishing.

Keho, Y. (2016). What drives energy consumption in developing countries? The experience of selected African countries. *Energy Policy, 91*, 233-246.

Kenya National Bureau of Statistics: KNBS (2010, 2013, 2015, 2016, 2017), *Statistical Abstract.* Nairobi: Government Printer.

Kenya National Bureau of Statistics: KNBS (2014), *Information on Revised National Accounts.* Nairobi: Government Printer.

Kenya National Bureau of Statistics: KNBS (2015, 2016, 2018), *Economic Survey.* Nairobi: Government Printer.

KIPPRA (2015), *Kenya Economic Report 2015*. Nairobi: Kenya Institute for Public Policy Research & Analysis.

Liu, X., Zhang, S., & Bae, J. (2018). Renewable energy, trade, and economic growth in the Asia-Pacific region. *Energy Sources, Part B: Economics, Planning, and Policy*, *13*(2), 96-102.

MOEP (2016), *Sustainable Energy for All Kenya Action Agenda.* Pathways for concerted action toward sustainable energy for all by 2030.

Ocal, O., & Aslan, A. (2013). Renewable energy consumption–economic growth nexus in Turkey. *Renewable and Sustainable Energy Reviews*, *28*, 494-499.

Odhiambo, N. M. (2010). Energy consumption, prices and economic growth in three SSA countries: A comparative study. *Energy Policy*, *38*(5), 2463-2469.

Ohlan, R. (2016). Renewable and nonrenewable energy consumption and economic growth in India. *Energy Sources, Part B: Economics, Planning, and Policy*, *11*(11), 1050-1054.

Onuonga, S. M. (2012). The relationship between commercial energy consumption and gross domestic income in Kenya. *The Journal of Developing Areas*, 305-314.

Ozturk, I. (2010). A literature survey on energy–growth nexus. *Energy policy*, *38*(1), 340-349.

Ozturk, I., Aslan, A., & Kalyoncu, H. (2010). Energy consumption and economic growth relationship: Evidence from panel data for low- and middle-income countries. *Energy Policy*, *38*(8), 4422-4428.

Parsa, H., & Sajjadi, S. Z. (2017). Exploring the Trade Openness, Energy Consumption and Economic Growth Relationship in Iran by Bayer and Hanck Combined Cointegration and Causality Analysis. *Iranian Economic Review*, *21*(4), 829-845.

Pesaran, M. H., & Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs*, *31*, 371-413.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, *16*(3), 289-326.

Republic of Kenya (2017), Budget Statement for the Fiscal year 2017/2018. Nairobi: The National Treasury

Romer D. (2012). *Advanced Macroeconomics (4th Edition*). New York: McGraw-Hill/Irwin

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.

Sadorsky, P. (2012). Energy consumption, output and trade in South America. *Energy Economics*, *34*(2), 476-488.

Şahbudak, E., & Şahin, D. (2016). Relationship between energy consumption, economic growth and trade openness in Turkey. *Journal of International Social Research*, *9*(42).

Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, *70*(1), 65-94.

Stern, D. I. (2004). Economic growth and energy. *Encyclopedia of Energy*, *2*(00147), 35-51.

Stern, D. I. (2010). The Role of Energy in Economic Growth' CCEP working paper 3.10. *Crawford School, the Australian National University*.

Stern, D. I., & Cleveland, C. J. (2004). Energy and economic growth. *Encyclopaedia of energy*, *2*, 35-51.

Tang, X., Deng, H., Zhang, B., Snowden, S., & Höök, M. (2016). Nexus between energy consumption and economic growth in China: From the perspective of embodied energy imports and exports. *Emerging Markets Finance and Trade*, *52*(6), 1298-1304.

Turner, P. (2010). Power properties of the CUSUM and CUSUMSQ tests for parameter instability. *Applied Economics Letters*, *17*(11), 1049-1053

Wang, S., Li, Q., Fang, C., & Zhou, C. (2016). The relationship between economic growth, energy consumption, and CO2 emissions: Empirical evidence from China. *Science of the Total Environment*, *542*, 360-371.

Wanjiku, E. W. (2011). *Impact of petroleum consumption on economic growth in Kenya* (Doctoral dissertation, University of Nairobi, Kenya).

Wolde-Rufael, Y. (2005). Energy demand and economic growth: the African experience. *Journal of Policy Modeling*, *27*(8), 891-903

Wolde-Rufael, Y. (2009). Energy consumption and economic growth: the experience of African countries revisited. *Energy Economics*, *31*(2), 217-224.

Wooldridge, J. M. (2012). Introductory Econometrics: A Modern Approach.

World Bank (2018). *World Development Indicators*. World Bank, https://data.worldbank.org/indicator

Zivot, E., & Andrews, D. W. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics*, *10*(3), 251-270.

Zweifel, P., Praktiknjo, A., Erdmann, G. (2017). *Energy Economics; Theory and Applications*. Springer

APPENDIX: DATA SET

The data set represents transformed data in per capita terms used in the study for the time period 1979 to 2014.

year	euse	pgdp	pgfcf	open
1979	453.7881	883.4167	144.4212	0.3699
1980	453.2893	898.0630	136.9661	0.3775
1981	448.7832	897.0657	138.2508	0.3164
1982	440.1224	876.4706	106.2266	0.2930
1983	431.2910	854.8411	92.1242	0.2628
1984	439.6016	837.7697	87.0797	0.2772
1985	442.1266	842.0730	81.4875	0.2682
1986	464.5828	870.2986	89.5490	0.2816
1987	466.9668	889.6342	94.6393	0.2803
1988	462.3821	912.3289	90.3394	0.2812
1989	463.3251	922.9814	91.3010	0.2943
1990	457.7252	930.0530	89.0406	0.3222
1991	451.3322	913.1102	88.8394	0.3096
1992	448.6545	877.3498	77.2819	0.3077
1993	445.7365	853.4356	81.8958	0.4060
1994	437.1611	849.6963	87.5599	0.4189
1995	444.6855	861.2491	92.1813	0.4142
1996	447.8110	871.4299	95.1505	0.4104
1997	440.5252	851.1836	95.3866	0.4071
1998	444.4661	855.0997	100.2798	0.3952
1999	441.8898	851.0677	96.8194	0.3987
2000	445.1247	833.0298	101.9845	0.4025
2001	439.0261	841.2205	111.5233	0.4350
2002	432.9136	823.0919	101.8837	0.4177
2003	430.5163	824.4702	91.2625	0.4195
2004	440.4319	843.2294	95.3200	0.4488
2005	443.9159	868.9228	118.5284	0.4755
2006	450.3058	900.1006	151.9274	0.5132
2007	447.6357	935.6565	151.0518	0.5051
2008	450.8316	912.3767	165.8407	0.5454
2009	464.4969	917.0438	177.4383	0.5425
2010	472.0566	967.3401	196.5809	0.5423
2011	468.9756	998.9984	200.4143	0.5709
2012	462.0974	1,016.8280	219.1967	0.5775
2013	475.8829	1,048.2690	217.9439	0.5395
2014	513.4265	1,075.6390	242.4216	0.5566

Key: euse (energy use), pgdp (per capita gdp), pgfc (per capita gfcf), open (trade openness).