EFFECT OF SELECTED MACROECONOMIC VARIABLES ON ENERGY CONSUMPTION IN KENYA

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DECLARATION

Declaration by the Student

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DEDICATION

This thesis is dedicated to my loving mother, Mary Aburuki, whose unwavering love, support, and encouragement have been my greatest source of strength throughout this journey. I am deeply grateful to my mentors and colleagues, whose guidance and insights have been invaluable to me. Finally, I dedicate this work to all those driven by curiosity and a passion for discovery, inspiring future generations of researchers.

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ABSTRACT

Energy utilization is critical for Kenya's economic development and its impact on industrialization and infrastructure development. The consumption of energy has been consistently increasing over the past 4 decades. The study examined the impact of economic growth, inflation rate, interest rates, trade openness, and foreign direct investment on energy consumption in Kenya. The study is pegged on Dependency Theory, Energy Ladder Theory and the Neoclassical Growth Theory. An explanatory research design was employed using secondary annual time-series data from 1980 to 2024. Structured review matrix and stationarity and cointegration tests were employed to collect data and prepare data for analysis such as descriptive statistics and ARDL model. Data stationarity was examined by applying the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Clemente-Montañés-Reyes tests to identify unit roots and structural breaks. The long-run and short-run connections between the variables were then explored using the ARDL model. The ARDL long run results showed that economic growth ($\beta = 0.1124$, $p = 0.166$) and inflation rate ($\beta = -0.0271$, $p = 0.197$) were statistically insignificant at the 5% significance level. The variable interest rate was found to significantly influence energy consumption with a negative β value of –0.0342 and p value of 0.038. Trade openness also had a significant negative effect ($\beta = -0.0158$, $p = 0.006$) while foreign direct investment had a significant positive impact ($\beta = 0.0205$, $p = 0.029$). The consumption (LD.) lagged difference was also high for energy consumption in Kenya in the short run. The size of the white-collar worker's family ($p = 0.009$, EN = 0.5537) is a significant factor affecting current demand. As interest rates go up, energy demand goes up (LD. RI = 0.0207, $p = 0.025$) due to delayed adjustment. Trade openness also contributes to short-term increase in energy use through the expansion of industry and export-oriented production (TOP = 0.0033, $p = 0.007$). Foreign Direct Investment initially reduces energy use (D1. FDI = –0.0100, $p = 0.012$), reflecting project lags and sectoral effects. The study finds that structural and external drivers like FDI, interest rates, and trade openness are more sensitive to energy use in Kenya than aggregate output growth or inflation. Based on that, the study suggests measures to encourage energy efficiency in investment by encouraging the inflow of green FDI with favourable conditions and improving monetary policy related to energy efficiency, and increasing trade liberalization by focusing on energy efficient and energy-technology industries.

Keywords

Energy Consumption, Economic Growth, Inflation Rate, Interest Rate, Trade Openness, Foreign Direct Investment, ARDL Model.

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LIST OF ABBREVIATIONS AND ACCRONYMS

ADF	Augmented Dickey-Fuller
AIC	Akaike Information Criterion
AO	Additive Outlier
ARDL	Autoregressive Distributive Lag
CMR	Clemente-Montañés-Reyes
COVID-19	Coronavirus Disease 2019
CUSUMSQ	Cumulative Sum of Squares
CS-ARDL	Cross-Sectionally Augmented Autoregressive Distributed Lags
EAC	East African Community
EPRA	Energy and Petroleum Regulatory Authority
EPZs	Export Processing Zones
ESCWA	United Nations Economic and Social Commission for Western Asia
FDI	Foreign Direct Investment
FPE	Final Prediction Error
GDC	Geothermal Development Company
GDP	Gross Domestic Product
HQIC	Hannan–Quinn Information Criterion
IEA	International Energy Agency
KenGen	Kenya Electricity Generating Company PLC
KIPPRA	Kenya Institute for Public Policy Research and Analysis

KNBS	Kenya National Bureau of Statistics
KPLC	Kenya Power & Lighting Company
KWh	Kilowatt- hours
LAPSSET	Lamu Port-South Sudan-Ethiopia Transport
LNG	Liquefied Natural Gas
LR	Likelihood ratio
NACOSTI	National Commission for Science, Technology, and Innovation
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
SAPs	Structural Adjustment Programs
SBIC	Schwarz Bayesian Information Criterion
SEZs	Special Economic Zones
TWh	Terawatt- hours
UECM	Unrestricted Error Correction Model
UNSDGs	United Nations Sustainable Development Goals
VIF	Variance Inflation Rate Factor

OPERATIONAL DEFINITION OF TERMS

Economic Growth: Increase in the quantity of goods and services an economy produces over a period, measured as a percentage of growth in real GDP (World Bank, 2023).

Energy Consumption: The total amount of energy used by a country, region, or sector, measured in units such as kilowatt-hours (kWh), terawatt-hours (TWh), British thermal units (BTUs), or gigajoules (GJ) (Sorrell & Speirs, 2021).

Foreign Direct Investment: An ownership stake in a foreign company or project made by an investor, company, or government from another country (World Bank, 2023).

Inflation Rate: The sustained increase in the general price level of goods and services in an economy (Mankiw, 2021).

Interest Rates: The proportion of a loan charged as interest to the borrower, expressed as an annual percentage of the loan amount (Mishkin, 2007).

Macroeconomic Variables: Indicators reflecting the overall pattern, performance, and structure in the context of the national economy or economy of a region. They enable economists, policy makers, and researchers to gain insight into the workings of an economy and inform fiscal, monetary and development policy decisions (Case, Fair, & Oster, 2017).

Trade Openness: The extent which a country permits goods and services to be exchanged with other countries, based on export-import to GNP. It captures whether the economy of a country is open or closed to foreign trade and how open a nation is to the rest of the world's economy (ESCWA, 2025)

CHAPTER ONE

INTRODUCTION

1.1 Overview

This section introduces the study topic, discusses the problem statement, the study's objectives, and the hypotheses formulated and tested.

1.2 Background Information

Energy consumption is a fundamental driver of economic growth and development, shaping industrial productivity, household welfare, and overall macroeconomic stability. It represents the total amount of energy used across sectors: households, industry, transport, and services, and is closely linked to economic transformation, infrastructure expansion, and living standards (Stern, 2019; IEA, 2024). Over the past two decades, Kenya has experienced a steady increase in energy demand driven by population growth, urbanization, industrial expansion, and rising household incomes (World Bank, 2023). While this relationship is important, the current empirical evidence on the impact of certain macroeconomic variables on Energy consumption in Kenya is still limited and fragmented.

This study therefore, narrows its focus to selected macroeconomic variables that are theoretically and empirically linked to energy consumption in Kenya. The selected variables include economic growth (real GDP), inflation rate, exchange rate, interest rate, and foreign direct investment. These variables were chosen based on their strong relevance to Kenya’s economic structure, their policy significance, and their documented influence on energy demand.

By examining the effects of these selected macroeconomic variables on energy consumption in Kenya, the study seeks to provide evidence-based insights that can inform macroeconomic and energy policy formulation. Understanding these relationships is essential for promoting efficient energy use, enhancing energy security, and supporting sustainable economic grow

1.2.1 Global Perspective

Energy consumption is a key driver of development worldwide.

Figure 1.1 below shows the Statistical Review of World Energy.

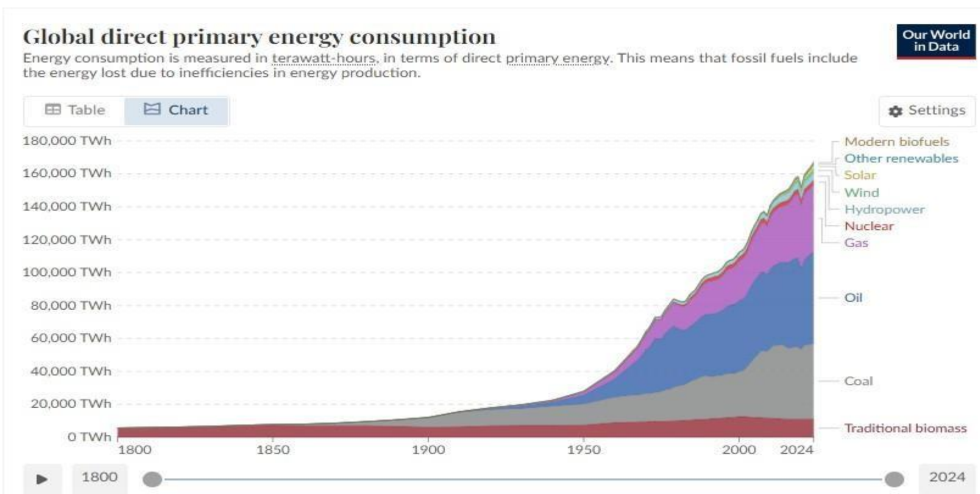

Figure 1.1: Global Direct Primary Energy Consumption

Source: Energy Institute - Statistical Review of World Energy (2025)

The global direct primary energy consumption has advanced rapidly.

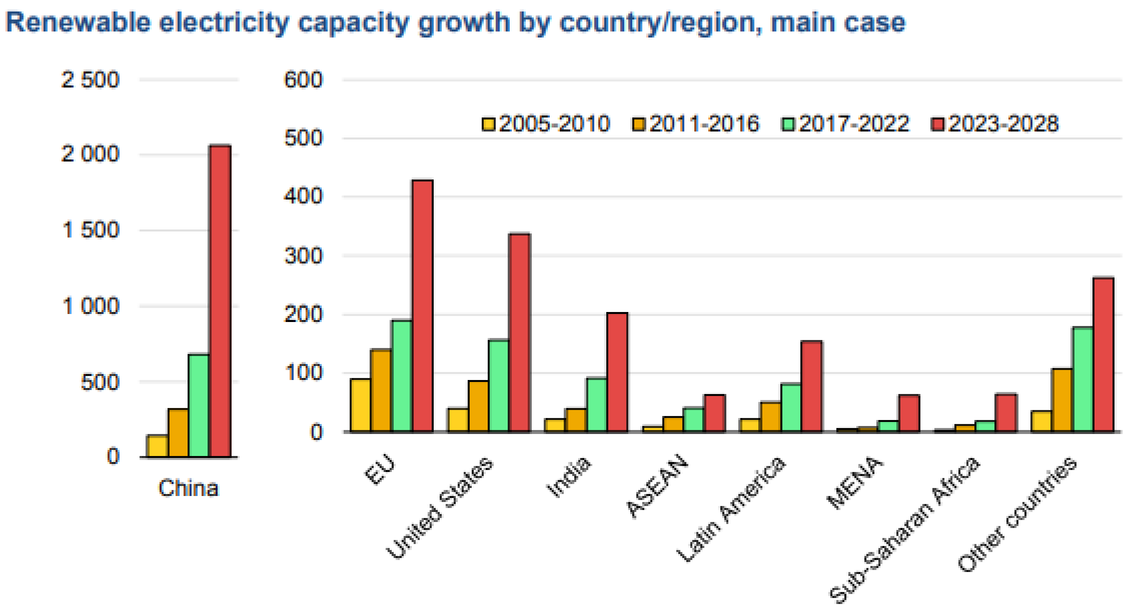

Figure 1.2: Renewable Electricity Capacity Growth by Country/region Source: IEA (2023)

In China, for example, energy consumption surged from about 20 EJ in 1980 to more than 160 EJ in 2022, making it the world's largest energy consumer. It's renewable electricity capacity growth tripled between 2023-2025 compared with the previous five years, with the country accounting for an unprecedented 56% of global expansion. The Chinese government's Net Zero by 2060 target, supported by incentives under the 14th Five-Year Plan (2021-2025) and the ample availability of locally manufactured equipment and low-cost financing, stimulate the country's renewable power expansion over the forecast period. This growth mirrors China's rapid industrialization and urbanization over the past 40 years (BP Plc, 2021).

Similarly, India's energy demand increased from around 6 EJ in 1980 to over 40 EJ by 2022, reflecting its expanding middle class and development of large-scale infrastructure (IEA, 2022). Progressive policy improvements to mediate auction participation, financing and distributed solar PV challenges pays off with faster renewable power growth through 2028. In contrast, OECD countries such as the United States and members of the European Union have experienced slower energy consumption growth and, in some cases, a plateau or decline. The United States, for example, saw energy use increase modestly from 80 EJ in 1980 to around 95 EJ in 2022, due largely to improvements in energy efficiency and a shift toward service-based economies (U.S. EIA, 2023). The increase has been exacerbated by the US Inflation Reduction Act (IRA) and country-level policy incentives supporting EU decarbonization and energy security targets. Simultaneously, these countries are under pressure to balance energy expansion with sustainability, especially amid rising energy prices and climate change commitments.

1.2.2 Regional Perspective

While maintaining the lowest per capita energy consumption globally, Sub-Saharan Africa has experienced steady growth in absolute energy demand over the past four decades. South Africa, by contrast, is the region's most energy-intensive economy, with primary energy consumption of approximately 5.8 EJ in 2022 (BP Plc, 2021). Its high energy use stems from mining, heavy industry, and transport, sectors that are central to its economy. However, more than 85% of South Africa's electricity is generated from coal, making it one of the continent's largest greenhouse gas emitters. Despite recent investments in renewables, coal dependence remains a structural constraint, linking the country's macroeconomic variables such as trade balances, inflationary pressures from coal exports, and interest-rate driven energy investment directly to consumption dynamics (Brunnhuber, 2025).

In Ethiopia, energy consumption rose from 0.25 EJ in 1990 to around 1.0 EJ by 2022, largely driven by ambitious hydropower expansion projects including the Grand Ethiopian Renaissance Dam (GERD) (IEA, 2022). Despite these investments, more than 65% of households continue to rely on traditional biomass due to low-income levels and inadequate rural infrastructure. This dual structure modern hydropower development coexisting with persistent biomass dependence illustrates the uneven nature of energy transitions in low-income African economies (Bekele, Ugo, & Chauhan, 2021). Recognizing energy's critical role, international frameworks like the Sustainable Development Goals and the African Agenda 2063 have prioritized sustainable energy practices for inclusive economic growth (Royo *et al*., 2022; Leal Filho *et al*., 2021).

The energy challenge is aggravated by the dynamics of fast-growing urbanization and industrialization pressures on a regional level. The UN projects that Sub-Saharan Africa's population will double by 2050, with urban areas absorbing most of this growth (United Nations, 2021). Urbanization often increases demand for modern energy sources such as electricity, petroleum, and natural gas, while industrialization raises energy intensity. Yet weak institutions, high borrowing costs, and limited foreign direct investment constrain the financing of new infrastructure. Cross-country evidence suggests that energy access remains highly unequal: while electrification rates surpass 80% in countries such as South Africa and Egypt, they remain below 50% in Nigeria, Tanzania, and the Democratic Republic of Congo (IEA, 2023).

1.2.3 National Perspective

Kenya, a lower-middle-income country in East Africa with over 55 million people, has experienced significant structural transformation in recent decades.

Alongside geothermal, Kenya has invested heavily in renewable projects such as the Lake

Turkana Wind Power Project (310 MW), one of Africa's largest wind farms, and extensive solar photovoltaic initiatives in both grid-connected and off-grid systems (World Bank, 2023). In Kenya, energy consumption has steadily increased over the past four decades, reflecting the country's efforts toward industrialization, urbanization, and economic transformation. From a consumption level of 0.084 BTU qn in 1987 to 0.304 BTU qn in 2023, this rise indicates a growing demand for electricity, petroleum products, and renewable sources to support expanding industries, infrastructure, and household usage (IEA, 2023). Petroleum products remain a dominant source of energy for transport and industry, accounting for nearly 25% of the national energy balance.

Meanwhile, traditional biomass still contributes close to 55% of total final energy consumption, reflecting persistent energy poverty in rural and peri-urban areas (IEA, 2023). The increase is also mirrored by a surge in electricity generation capacity, major renewable energy projects such as geothermal plants in Olkaria and wind farms in Turkana, and broader access to off-grid solutions. Kenya's installed geothermal capacity is approximately 943.7 MW and has set to add 1,500 MW of green energy capacity by 2034 (including about 800 MW from geothermal sources) (World Bank, 2023). However, this growth faces challenges, including energy poverty, economic constraints, and infrastructural limitations (Smith & Jones, 2021). As Kenya strives to achieve SDG 7 (affordable and clean energy), understanding what drives this upward trend in energy demand is essential (Khan *et al*., 2019).

The surge has been exacerbated by various macroeconomic variables, such as inflation rates, interest rates, trade openness, and foreign direct investment, which significantly affect energy consumption patterns (IEA, 2021). Economic growth has remained moderately strong, averaging about 5% over the past decade, with periods of accelerated growth during infrastructure expansion and diversification of the economy, fueling higher demand for electricity and petroleum products (KNBS, 2023). Foreign Direct Investment (FDI) inflows, which rose significantly after 2010 with large projects such as the LAPSSET corridor, renewable energy plants, and ICT hubs, have stimulated energy-intensive industrial and infrastructural activities (UNCTAD, 2021). Inflation, while historically volatile, particularly during the early 1990s, has stabilized the last two decades, hence more predictable household energy consumption patterns (CBK, 2020). Interest rate liberalization in the 1990s introduced fluctuations in credit availability, with lower rates in recent years boosting access to energy technologies and household connectivity (IMF, 2018). At the same time, Kenya's trade openness, driven by the East African Community (EAC) Common Market and rising engagement with China and other emerging partners, has encouraged the importation of modern technologies and energy-efficient equipment, directly influencing energy use in industry and transport (World Bank, 2016).

Kenya's energy policies are guided by long-term national development frameworks such as Vision 2030 and the National Energy Policy, which emphasize universal access, diversification of energy sources, and expansion of renewable energy. Regional integration through the Eastern Africa Power Pool (EAPP) also plays a role, as Kenya seeks to export surplus electricity to neighboring countries such as Uganda, Tanzania, and Ethiopia. Nevertheless, the sector continues to face challenges including high system losses (above 20%), rising tariffs, inadequate financing for large projects, and heavy reliance on hydropower during dry periods (EPRA, 2022).

The result has been a shift towards renewable energy sources such as coal, wind power, and solar. Developed countries, driven by environmental policies and technological innovations, are increasingly investing in renewable energy, which impacts global energy markets and consumption trends (IRENA, 2023). Developing countries still lag in transitioning to renewable energy due to economic constraints and infrastructure limitations (Smith & Jones, 2021).

1.3 Statement of the Problem

Kenya's energy sector has grown significantly through investments in renewable energy sources and infrastructure. Despite these efforts, energy consumption patterns in the country remain inconsistent with broader economic growth objectives, characterized by persistent inefficiencies, uneven access, rising demand pressures, and growing concerns over sustainability. While energy demand continues to increase alongside population growth and economic expansion, the responsiveness of energy consumption to key macroeconomic conditions remains insufficiently understood. For decades now, biomass is reported as the dominant energy source in Kenya, accounting for about 68% of the energy utilized (Mai-Moulin, Dardamanis, & Junginger, 2016). Other major energy sources accounting for the total energy consumed include petroleum products and electricity at 22% and 9%, respectively (Owiro *et.al*, 2021). Around 90% of rural households rely on biomass for basic energy needs like cooking, heating, etc, while approximately 68.5% of both urban and rural households still use traditional biomass fuels (IEA, 2013). In addition to posing significant health hazards, this dependence on non-renewable and environmentally harmful energy sources also fuels deforestation, greenhouse gas emissions, and economic vulnerability.

Despite increased generation capacity through geothermal plants in Olkaria, wind farms in

Turkana, and broader off-grid solutions, Kenya's electricity sector continues to face a widening gap between demand and supply. In the past year, Kenya generated 14,472 GWh, but only 11,329.88 GWh were consumed, with nearly a quarter (23.36%) lost due to technical and commercial system inefficiencies, well above the Energy and Petroleum Regulatory Authority's (EPRA) target of 17.5%. Demand surged to 2,316 MW, up 6.4%, while generation grew 5.8%, further straining the national grid.

Other sectors which rely on biomass include the industries micro and small enterprises which face challenges in adopting sustainable energy technologies when energy costs remain unstable and expensive (World Bank, 2023). Addressing these gaps is essential for improving energy planning, enhancing policy coherence, and supporting sustainable economic development.

1.4 Objectives of the Study

1.4.1 General Objective

The general objective was to examine the effect of selected macroeconomic variables on energy consumption in Kenya.

1.4.2 Specific objectives

The specific objectives of the study were as follows:

i. To assess the effect of economic growth on energy consumption in Kenya

ii. To determine the effect of inflation rate on energy consumption in Kenya.

iii. To evaluate the effect of interest rate on energy consumption in Kenya.

iv. To examine the effect of trade openness on energy consumption in Kenya.

v. To establish the effect of foreign direct investment on energy consumption in Kenya.

1.5 Research Hypotheses

The study tested the following null research hypotheses;

H_{O1}: Economic growth has no significant effect on energy consumption in Kenya.

H_{O2}: Inflation rate has no significant effect on energy consumption in Kenya.

H_{O3}: Interest rate has no significant effect on energy consumption in Kenya.

H_{O4}: Trade openness has no significant effect on energy consumption in Kenya.

H_{O5}: Foreign direct investment has no significant effect on energy consumption in Kenya.

1.6 Significance of the Study

This study makes an important contribution to energy economics and policy formulation in Kenya by providing an empirical assessment of how selected macroeconomic variables influence energy consumption. By systematically analyzing the roles of economic growth, inflation, interest rates, trade openness, and foreign direct investment, the study generates evidence that enhances understanding of the macroeconomic drivers of energy demand within a developing country context.

The results will be used to integrate macroeconomic parameters into energy planning and energy demand forecasting for the country by the Ministry of Energy. The Ministry's knowledge of the relationship between economic growth and energy use helps develop energy policies that are sensitive to structural shifts in the economy, facilitate the shift to clean energy and influence energy supply planning to meet long-term development goals. Moreover, the study would be relevant for the Energy and Petroleum Regulatory Authority (EPRA) as it would offer them information about the influence of inflation, interest rates and trade of energy consumption behaviour of the sectors. Such knowledge can be used to design regulatory, tariff and demand-side management policies that result in higher efficiency, lower system losses and more reliable supply of energy.

1.7 Scope of the Study

This study examined the effects of selected macroeconomic variables on energy consumption in Kenya over the period 1980 to 2024. The chosen study period was important in showing how energy consumption evolved overtime due to socio-economic patterns during major transformations such as urban development, technological progress, change of regimes, and regulatory modifications. The dependent variable was total energy consumption, encompassing electricity, petroleum products, biomass, and renewable energy sources. The independent variables under investigation included economic growth (measured by GDP), inflation rate, interest rate, trade openness, and foreign direct investment (FDI). The study was confined to Kenya, providing a country-specific analysis that reflected the local economic structure, energy policies, and consumption behavior. Annual time-series data were sourced from reputable institutions such as the Kenya National Bureau of Statistics (KNBS), and the World Bank. The research employed the Autoregressive Distributed Lag (ARDL) model to analyze both the short-run and long-run dynamics between the variables. The scope excluded micro-level household energy behavior and did not cover policy implementation assessment. Instead, it offered a macro-level empirical perspective to inform policymakers, energy planners, and development partners on the interplay between macroeconomic conditions and energy demand in Kenya.

1.8 Assumptions of the Study

This study was guided by several assumptions. First, it was assumed that the relationship between the selected macroeconomic variables: GDP, inflation rate, interest rate, trade openness, foreign direct investment, and energy consumption in Kenya is linear and stable over the study period, thereby allowing meaningful estimation through the ARDL framework. Second, the study assumed that the secondary data obtained from reputable sources such as the Kenya National Bureau of Statistics (KNBS), and the World Bank were accurate, consistent, and reliable for capturing macroeconomic and energy consumption trends in Kenya.

In addition, it was assumed that the exclusion of other socioeconomic determinants such as population growth, urbanization, and energy prices would not substantially bias the results within the scope of the current model. Finally, the study assumed that the variables under investigation either become stationary after differencing or exhibit cointegration, thus justifying the application of the ARDL model to examine both the short-run and long-run dynamics.

1.9 Limitations of the Study

Limitations refer to potential weaknesses or constraints in a study's design, scope, or methodology that may affect the interpretation or generalizability of its findings. They arise from factors beyond the researcher's control, such as data availability, measurement challenges, resource constraints, or methodological choices (Simon & Goes, 2011). Despite its contributions, this study was subject to certain limitations. First, the analysis focused exclusively on macroeconomic variables; GDP, inflation rate, interest rates, trade openness, and foreign direct investment while excluding other potentially relevant socioeconomic factors such as population growth, urbanization, energy prices, and technological progress. Omitting these variables may limit the model's comprehensiveness.

In addition, the study was confined to the Kenyan context where structural, institutional, and policy environments may differ significantly. The reliance on secondary data from sources such as KNBS, and the World Bank also posed a limitation, as such data may contain reporting lags, measurement inconsistencies, or revisions that could affect results.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section presents findings from other studies, grounded in specific objectives and anchored in empirical and theoretical perspectives. This chapter reviews the theoretical and empirical literature related to the relationship between macroeconomic variables and energy consumption. It establishes the theoretical foundation underpinning the study, critically evaluates empirical findings from global, regional, and Kenyan contexts, and identifies gaps that justify the present research. The review specifically examines how selected domestic and external macroeconomic variables influence energy consumption, consistent with the study's objectives.

2.2 Theoretical Literature Review

According to Kivunja (2018), a theoretical framework is a set of coherent ideas and principles that explain observed phenomena. Energy consumption is linked to macroeconomic performance through production, investment, trade, and consumption channels. To explain this relationship comprehensively, the study adopted an integrated theoretical framework drawing from Neoclassical Growth Theory, Energy Ladder Hypothesis, and Dependency Theory. These theories jointly explained how domestic and external macroeconomic conditions shape energy demand patterns in developing economies such as Kenya.

2.2.1 Dependency Theory

Dependency Theory, first proposed in the late 1950s by the Argentine economist and statesman Raúl Prebisch, posits that the economic development of developing nations is heavily influenced by their historical and structural relationships with more developed nations (Gessi, 2024). It argues that developing countries are often locked in a state of dependence on developed countries due to unequal exchange, whereby resources flow from periphery (developing) countries to core (developed) countries, exacerbating poverty and underdevelopment in the former (Cardoso & Faletto, 2024). This study integrates dependency theory with an exploration of foreign direct investment, trade openness, interest rate, economic growth, and inflation rate to understand the drivers of Kenya's energy consumption pattern. However, factors that are external to Kenya i.e. the need to adopt imported technologies that are foreign sourced and global variation in energy prices also have an influence on energy consumption.

ENC= f (GDP, RI, INF, FDI, TOP)

Where:

ENC represents energy consumption

GDP represents economic growth

RI denotes interest rate

INF refers to the inflation rate (influenced by global markets)

FDI denotes foreign direct investment

TOP represents trade openness

This equation highlights that energy consumption in a developing country like Kenya is influenced by local economic growth and external economic and trade factors (Foreign Direct Investments, trade openness, inflation rate, and interest rates). This conceptualization is consistent with Dependency Theory, which posits that the economic trajectories of developing countries are significantly shaped by their reliance on external capital flows, trade structures, and global financial conditions (Cardoso & Faletto, 2024).

In the Kenyan context, dependency on foreign direct investments limits local capacities and hinders the development of a sustainable energy sector since much of the energy infrastructure and resources are imported or controlled by foreign entities (Odhiambo, 2022). In analyzing the effect of selected macroeconomic variables on energy consumption in Kenya, Dependency Theory provided a critical lens in examining the impact of international relationships on local energy policies and consumption patterns. For instance, Kenya's reliance on foreign direct investment for local energy production leads to an increased inflation rate resulting from higher costs of goods and services and limited access for the local population, thereby influencing overall consumption rates (Makundi & Ochieng, 2022).

Additionally, fluctuations in global prices, driven by factors external to Kenya, for example, the COVID-19 pandemic and the Russia-Ukraine war, significantly affect the country's inflation rate levels, thus affecting energy consumption dynamics and reinforcing the dependency cycle. Therefore, the study was necessary in addressing energy consumption in Kenya by understanding local macroeconomic variables and analyzing how global economic relations shape these factors, ultimately impacting energy availability and affordability (Khamis & Were, 2023).

2.2.2 Energy Ladder Hypothesis

Drawing upon dependency theory, this study also examined internal factors influencing energy consumption in Kenya through the Energy Ladder Hypothesis, which was first introduced by Hosier & Dowd (1987) who sought to explain the transition of energy use patterns in developing countries undergoing economic development. As firms expand and industrialize, their financial and technical capacity increases, enabling a shift toward more modern, reliable, and cleaner energy sources, including electricity, liquefied petroleum gas (LPG), and eventually renewable sources like solar, wind, and bioenergy (Von Weizsäcker *et al*., 2014). Trade openness facilitates this transition by enabling access to advanced technologies, capital goods, and energy-efficient production methods. In this context, increased integration into global markets is expected to influence both the scale and structure of energy consumption (Antweiler, Copeland, & Taylor, 2001). By integrating dependency and energy ladder theories, this study comprehensively analyzes the external and internal factors shaping energy consumption in Kenya.

2.2.3 Neoclassical Growth Theory

The Neoclassical Growth Theory was first developed by Robert Solow (1956) and later extended by Trevor Swan (1956). The theory came as an answer to the previous growth models as it gave a systematic explanation about the long run economic growth in terms of accumulation of factor inputs and technological progress. The theory suggests that economic growth is determined by the interaction between three factors of production – capital (K), labour (L) and technology (A) – in the production function, which can be expressed as F (K, L, A). Y= Af (K, L) where Y is the output, K is physical capital (amount of capital used), and L is labour (amount of labour used), and A is technology. Thus, it is argued that in the short run, the determinants of economic growth are increases in capital and labour, while in the long run, it is the exogenous technological innovation that is a driver of sustainable economic growth (Solow, 1956).

2.3 Study Concepts

The aim of the study was to investigate the effect of macroeconomic factors on energy consumption in Kenya. The dependent variable (energy consumption) is the total energy consumption of an economy, encompassing electricity, petroleum, biomass, and renewable energy sources (IEA, 2023). It is well established that economic growth – GDP – is linked to a rise in energy demand, which is attributed to the increase in industrialisation and infrastructure development (Stern, 2019 The effect of inflation on energy consumption can be seen in terms of the purchasing power of consumers and the production cost.

2.4 Empirical Literature Review

This section analyzed existing research and data to understand and contextualize how specific factors influence a particular phenomenon (Kivunja, 2018). In this study, the empirical review examined studies and data on how macroeconomic variables, such as economic growth, interest rates, inflation rates, trade openness, and foreign direct investment, affect energy consumption patterns in Kenya, providing evidence-based insights to guide the research (Stern, 2019; Chen & Lin, 2021).

2.4.1 Economic Growth and Energy Consumption

Empirical evidence consistently demonstrates a strong relationship between economic growth and energy consumption, though causality varies across countries and regions. The present study makes the data current to 2024 to capture current policy evolution and technology developments bringing the energy–growth relationships in Kenya to date; thus, the present study makes a more up-to-date contribution to the literature.

2.4.2 Inflation Rate and Energy Consumption

Mehrara and Rezaei (2015) analyzed panel data from oil-exporting developing countries (1980– 2012) and found that inflation had a significant negative effect on energy consumption. Their results echo Jamil and Ahmad's (2010) findings in Pakistan, where rising electricity prices reduced demand and pushed households toward cheaper but less efficient alternatives. Similarly, Shahbaz and Lean (2012) highlighted in Tunisia that inflationary shocks not only dampened household consumption but also undermined long-term investment in energy infrastructure. Taken together, these studies suggest that inflation poses a major barrier to energy sector growth. However, they generalize across diverse settings without incorporating critical factors such as subsidy regimes, income levels, or energy price structures, and they overlook more recent global shocks. The current study builds on this body of work by updating the analysis and applying it to Kenya, where subsidy reforms, rural–urban migration, and informal sector dynamics may reshape the inflation–energy nexus.

A study by Yilanci and Aydin (2017) showed that inflation influences energy consumption through price and cost channels, but their focus on Turkey limits contextual relevance. In Kenya, inflation volatility and interest rate fluctuations are pronounced, yet few studies explicitly examine their role in shaping energy demand. This gap limits policymakers' ability to design macro-energy-coordinated interventions. Evidence from Turkey by Yılmaz and Altay (2016) further shows that inflation causes a short-run decline in energy demand, particularly among households and small businesses, a pattern also observed by Narayan and Smyth (2005) in Australia.

2.4.3 Interest Rate and Energy Consumption

Were, Ndung'u, and Geda (2002) showed that in Kenya, high interest rates constrained private investment and public infrastructure financing, slowing the expansion of electricity access and industrial energy use.

2.4.4 Trade Openness and Energy Consumption

Trade openness influences energy consumption through scale, technique, and composition effects. Antweiler *et al.* (2001) argue that increased trade can raise energy consumption by expanding production while simultaneously improving energy efficiency through technology transfer. Conversely, a survey of the Asian economies by Lee and Chang (2007) showed that the Asian economies were less sensitive to interest rates in energy demand because of structural reforms and enhancement of the energy sector that rendered them less sensitive to monetary policy. This split illustrates why the institutionalization and financial maturity of an economy can help to moderate the energy–interest rate relationship.

2.4.5 Foreign Direct Investment and Energy Consumption

Omri *et al*. (2014) undertook a comprehensive panel study across 65 countries between 1990 and 2011 using cointegration and causality techniques. The results showed the presence of both a forward and reverse causalities between FDI and energy consumption, from which it could be inferred that FDI creates energy demand, and energy demand brings in more foreign capital especially for middle-income economies which have better infrastructure. The findings affirm the notion that FDI is a demand promoter as well as a result of energy utilization. The diversity of the sample, however, calls into question the generalizability of the results: the mechanisms that link FDI to energy demand vary from one economy to the other, depending on their level of development, resource endowment and policy regime.

Conversely, Al-Mulali and Ozturk (2016) identified that causality runs only from FDI to energy consumption in the Gulf Cooperation Council (GCC) countries. The study emphasized that the energy subsidies and resource-based investments in these economies have affected the two-way relationship identified in the global sample by Omri et al. (2014). Rather, FDI mainly serves as a catalyst to energy demand in the GCC states without a feedback effect. In Kenya, studies on FDI largely focus on economic growth and employment, leaving its impact on energy consumption underexplored (Odhiambo, 2022).

Finally, Ouedraogo (2013), examining West African economies, emphasized the asymmetry of FDI’s effects. The study found that while FDI inflows stimulated energy demand in resource- intensive sectors such as mining, the absence of complementary infrastructure limited the broader diffusion of investment into energy-efficient technologies. This perspective contrasts with Kenya’s trajectory, where investments in geothermal and wind energy projects illustrate how FDI can be harnessed to promote cleaner growth. The current study builds on these insights by situating Kenya’s experience within the broader debate, testing whether FDI inflows are driving energy- intensive consumption or supporting efficiency-enhancing transitions consistent with long-term sustainability goals.

2.5 Review of Empirical Models

This section involves examining various econometric approaches used to scrutinize the relationship between energy consumption and macroeconomic variables. Common models such as Autoregressive Distributed Lag (ARDL), Multivariate Regression Analysis, and Vector Autoregressive (VAR) models are common in enabling to understand both short-term and long- term influences on energy consumption.

2.5.1 Autoregressive Distributed Lag (ARDL) Model in Energy Consumption Studies

The ARDL model, particularly the bounds testing approach developed by Pesaran, Shin, and Smith (2001), has gained prominence in empirical studies examining the relationship between energy consumption and macroeconomic variables. Its popularity stems from its flexibility in handling variables that are integrated of order I (0), I (1), or a mix of both, and its ability to capture both short-run and long-run dynamics in a single framework.

2.5.2 Vector Autoregressive (VAR) Model in Energy Consumption Studies

The Vector Autoregressive (VAR) model, introduced by Sims (1980), has been widely used in energy economics to capture the dynamic interrelationships among energy consumption, economic growth, and macroeconomic variables without imposing strict theoretical restrictions on causality.

Apergis and Payne (2009) applied panel VAR methods to 11 Central American countries and found bidirectional causality between energy consumption and economic growth, thereby reinforcing the feedback hypothesis at the regional level. More recently, Lean and Smyth (2010) employed a panel VAR for ASEAN countries and found that energy consumption and economic growth are cointegrated, with significant bidirectional causality, highlighting the interdependence between energy demand and economic performance in emerging economies.

2.5.3 Multivariate Regression Analysis in Energy Consumption Studies

Multivariate regression analysis has been one of the earliest and most widely used econometric tools. It allows researchers to isolate the net effect of each macroeconomic factors while controlling for others. This makes it particularly useful in cross-country analyses and national- level studies where the goal is to assess broad drivers of energy demand. However, the method assumes linearity, stationarity, and independence of errors, which may limit its ability to capture dynamic feedback effects or long-run cointegration often observed in energy–macroeconomic relationships (Wooldridge, 2016).

One of the foundational applications of multivariate regression in energy studies was by Kraft and Kraft (1978), who investigated the causal relationship between energy consumption and economic growth in the United States.

More recent studies have extended the use of the multivariate regression in the developing countries. Kahouli (2018), for instance, applied multivariate regression analysis with macroeconomic and financial variables to the case of Tunisia, and revealed that, in addition to GDP, financial development and trade also influence energy consumption. Kiplagat, Wang and Li (2011) in Kenya developed a multivariate model to estimate trends of energy demand and identified population growth, urbanization and economic growth as important factors for predicting energy demand in the long run.

2.6 Identification of Knowledge Gap

The empirical literature review provided various findings regarding the degree to which macroeconomic variables influence energy consumption, resulting in the study gaps.

Table 2.1 below shows the research gaps.

Table 2.1: Summary of Knowledge Gap

Author and Year	Objective of the study	Key Findings	Knowledge Gaps	Focus of the Current Study
Sifuna (2019)	Exploring the influence of economic growth on energy consumption globally.	There is a positive correlation between economic growth and energy consumption across countries.	The study analyzes data from 1979 to 2014.	Using more recent data in Kenya's energy sector.
Okonkwo and Uncle (2018)	Investigating the role of inflation rate on energy consumption.	Inverse relationship.	The study does not provide long-run relationship between variables.	Explore the long-run relations.
Law & Sek (2022)	Examining the effect of trade openness on energy consumption.	Unidirectional relationship.	The study does not address structural economic shifts.	Explore sector specific energy demands.
Omri *et.al* (2014)	Exploring the relationship between FDI and energy consumption.	Bidirectional causal relationship between FDI and energy consumption.	The study does not consider developing countries and their dynamics.	Addressing diverse economic contexts of developing countries.
Macharia, Gathiaka & Ngui (2022)	Effect of trade openness on energy consumption.	Increased exports and R&D result to efficient energy use.	Other key sectors, such as agriculture and services, are overlooked.	The study factored in all dynamic sectors of developing countries.
Lee and Chang (2008)	Investigated economic growth and energy use using panel data across multiple countries.	Positive correlation between GDP per capita and energy use.	Does not capture country-specific dynamics such as informal sector growth and urbanization in Kenya.	Connect global insights to Kenya's structural realities.
Mehrara (2015)	Studied oil-exporting developing countries on GDP–energy dynamics.	Found unidirectional causality from GDP to energy use.	Focuses on oil-exporting economies with subsidies; less relevant for energy-importing Kenya.	Test causality in Kenya's context as an energy-importing country.
Kalkuhl, Edenhofer & Lessmann (2016)	Examined economic growth's role in transition to renewable energy.	Growth drives renewable adoption but mediated by policy.	Did not examine FDI, trade, or Kenya's specific policy frameworks.	Integrate renewable transition with Kenya's FDI and trade context.

Mehrara & Rezaei (2015)	Panel study on oil-exporting countries (1980–2012).	Inflation rate reduces energy consumption.	Focuses on diverse countries with subsidies; excludes recent global shocks.	Conduct Kenya-specific analysis considering import dependence and renewables.
Shahbaz & Lean (2012)	Analyzed inflation and energy demand in Tunisia.	Inflation reduces household use and investment in energy.	Focuses on Tunisia; ignores subsidy policies and broader context.	Address Kenya-specific inflation effects on investment and demand.
Yılmaz and Altay (2016)	Examined inflation–energy causality in Turkey.	Inflation reduces short-run energy demand.	Provides little insight on long-run adaptations.	Incorporate long-term effects in Kenya's context.
Narayan & Smyth (2005)	Studied inflation effects in Australia.	Inflation reduced household electricity demand.	Developed economy focus; less relevant to developing countries.	Apply framework in Kenya's inflationary context.
Bildirici, Bakirtas, and Kayikci (2012)	Studied inflation and energy dynamics in selected countries.	Inflation may increase nominal energy demand (anticipatory use).	Does not specify structural factors driving results.	Test nonlinear inflation–energy dynamics in Kenya.
Omri & Kahouli (2014)	Panel of 65 countries: interest rate, FDI, growth, and energy.	Found bidirectional relationships.	Ignores country-specific institutions.	Tailor findings to Kenya's context.
Zhang & Cheng (2009)	Studied monetary policy in China.	High interest rates reduced industrial energy demand.	Single-country study; sectoral analysis limited.	Apply monetary policy–energy framework to Kenya
Sadorsky (2010)	Examined U.S. and EU.	Interest rates affect energy through cost of capital.	Assumes homogeneity in consumer responses	Factor in cultural and structural differences in Kenya.
Lee & Chang (2007)	Panel of Asian economies.	Financial deepening reduced energy sensitivity to interest rates.	Context differs from Africa's financial systems.	Compare Kenya's vulnerability to monetary shocks.
Omri et al. (2014)	Panel of 65 countries on FDI, growth, and energy.	Found bidirectional causality.	Overgeneralizes across economies.	Focus on Kenya as a developing country with unique dynamics.
Osabuohien & Drapkin (2022)	OECD countries: FDI, trade openness & energy.	Outward FDI leads to energy efficiency gains.	Energy efficiency gains. Limited to OECD; not generalizable.	Contextualize findings for Kenya.

2.7 Limitations of Empirical Literature

The empirical reviews highlighted in the table revealed several limitations that underscored the need for further research, particularly in Kenya. One is that many of the studies mainly concentrated on the developed countries, overlooking the specific economic situation in the developing countries. To illustrate this point, Sifuna (2019) has conducted research on the two- way relationship between energy use and economic growth with specific consideration to those nations that are developed, leaving a huge gap in the body of knowledge that would be important to understand how the relationship would be in Kenya as a developing country having varying level of industrialization and energy infrastructure. This omission makes the research results less generalized to other situations where the energy consumption is not as closely related to economic growth, and may lead to an inaccurate interpretation of policy implications.

2.8 Theoretical Framework

The framework is anchored on the Ecological Modernization Theory (EMT), which was first introduced by Joseph Huber in the early 1980s and was later expanded by scholars such as Arthur P. J. Mol and Gert Spaargaren (Mol & Spaargaren, 2000). This theory suggests that with proper use of modern institutions, markets, and technologies, economic growth can have an impact on sustainable energy consumption. EMT believes that macroeconomic advancements such as FDI and trade openness can lead to the use of cleaner energy and the improvement of energy efficiency through innovation and regulatory changes, particularly in developing countries (Huber, 1982). As economies expand and open to the world, they adopt high technologies and environmental criteria and finally more sustainable energy use patterns. For the Kenyan situation, EMT implies that, if managed strategically, macroeconomic growth can drive a transition towards renewable energy and better energy infrastructure via international cooperation and environment-friendly investments. In this sense, EMT backs the hypothesis that economic growth can be a mechanism to de-couple energy use from environmental degradation if the growth is consistent with environmental policies, thus providing an alternative path to achieving sustainable development.

2.9 Conceptual Framework

A conceptual framework is a structured plan or system to outline the main concepts, theories, and variables guiding a research study (Kivunja, 2018). It provides a visual or narrative representation of the relationships between different concepts and how they are expected to influence one another. This framework helps organize and define the scope of the research, guiding objective development and providing a basis for interpreting the findings. The conceptual framework incorporated the independent and dependent variables, guided by the study's objectives.

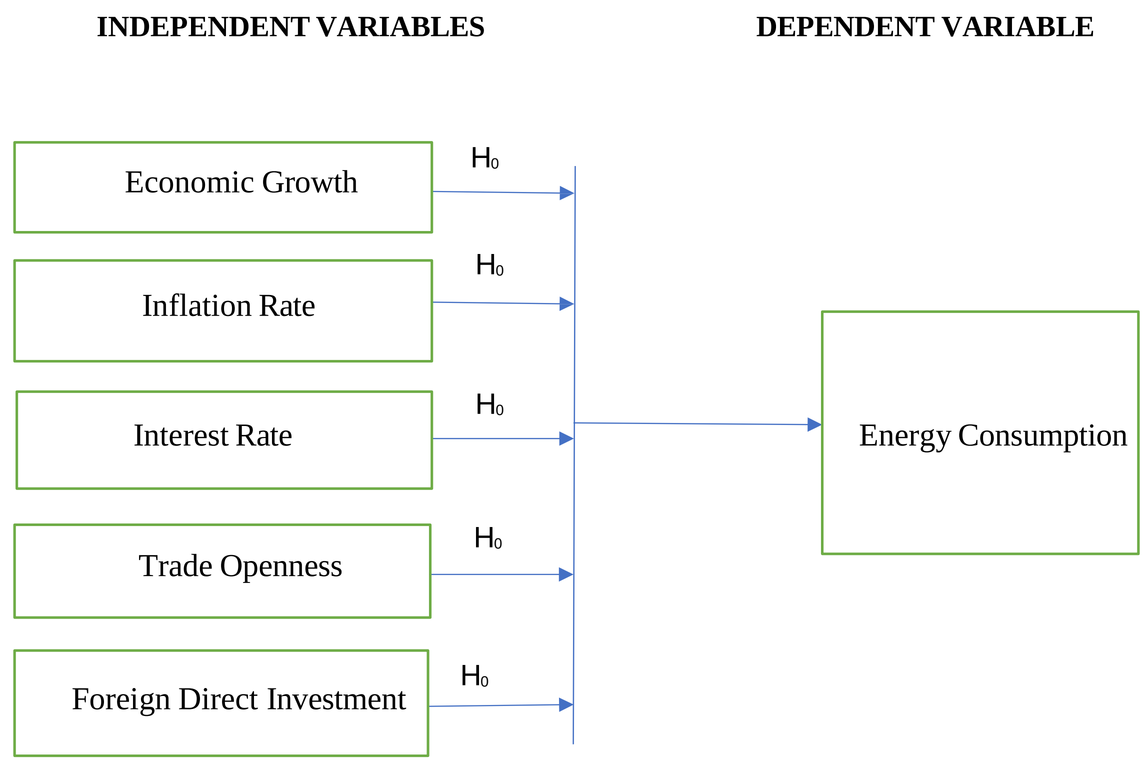

Figure 2.1: Conceptual Framework

Figure 2.1 is the conceptual framework, which shows the effects of independent variables: economic growth, inflation rate, interest rate, trade openness, and foreign direct investment on the dependent variable, which is energy consumption.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter presents the methodology, research design data collection instruments, study area, and the methods and procedures used. Additionally, the chapter outlines the data analysis techniques and procedures that were implemented.

3.2 Research Design

The study adopted a quantitative, explanatory time-series research design to identify the relationship between selected macroeconomic variables and energy consumption in Kenya (Creswell, 2009). The design was appropriate because the study sought to establish causal, long-run relationships between macroeconomic indicators and national energy consumption over time rather than to describe trends (Gujarati & Porter, 2009; Wooldridge, 2016).

The explanatory design enabled the researcher to assess how changes in economic growth, inflation rate, interest rate, trade openness, and foreign direct investment influence energy consumption dynamics in Kenya. Time-series analysis was suitable given that the variables under investigation exhibit temporal behavior and are influenced by past values. This approach allowed identifying both short-run adjustments and long-run equilibrium relationships among the variables, thereby providing a robust empirical basis for policy-relevant conclusions.

3.3 Study Area

The study was undertaken in Kenya, a country located in East Africa along the equator, with a coastline on the Indian Ocean to the southeast. It is ethnically diverse with major ethnic groups being Kikuyu, Luhya, Luo, Kalenjin and Maasai among others (KNBS, 2023). One of the characteristic trends is the steady increase of the urban population, which stands at more than 28% of the total population, according to the World Bank (2023), and has been rapidly increasing due to urbanization.

Additionally, Kenya is classified as a lower-middle-income country (World Bank, 2024). It is considered the economic hub of East Africa where multinational companies and international organisations and financial institutions have their regional offices (Mwangi, 2021). Kenya is a diversified economy which comprises agriculture, manufacturing, services and an emerging energy sector. Agriculture is still the mainstay accounting for approximately 20 – 22% of GDP, and provides substantial employment for rural people, the major agricultural exports are tea, coffee and horticultural products (Makau, Ocharo, & Njuru, 2018). Services (particularly tourism), financial services and ICTs has been one of the main growth areas, and the manufacturing sector has received help from government policies on industrialization in Kenya for Vision 2030 (The National Treasury and Economic Planning, 2021).

In 2024, Kenya had an estimated GDP of USD 95 billion, ranking it among the largest economies in Sub-Saharan Africa, without South Africa and Nigeria (KNBS, 2023; The National Treasury, 2024). The last ten years have been characterized by massive investment in infrastructure in terms of roads, rail, energy and digital connectivity to propel economic growth. Notably, the government has strategically invested in the energy sector, focusing on renewable sources such as geothermal, wind, and solar, making Kenya a global leader in geothermal development (World Bank, 2023).

Energy consumption in Kenya has grown sharply in recent years, reflecting rising industrialization, urbanization, and household demand. According to KNBS (2023), energy consumption rose by nearly 180% between 2013 and 2023, with energy imports also increasing by 65.74% in 2023 alone. Despite increased investments in renewable energy, traditional biomass mainly firewood and charcoal still dominate with more than 65% of total primary energy, especially in rural areas (Mai-Moulin, Dardamanis, & Junginger, 2016). The national electricity access rate stood at 75% in 2022, although disparities persist between urban and rural households (IEA, 2022). Kenya's energy policy framework, particularly Vision 2030 and the National Energy

Policy, emphasizes diversification of the energy mix, expansion of renewable energy, and universal energy access.

Figure 3.1 below is the map of Kenya indicating the study area.

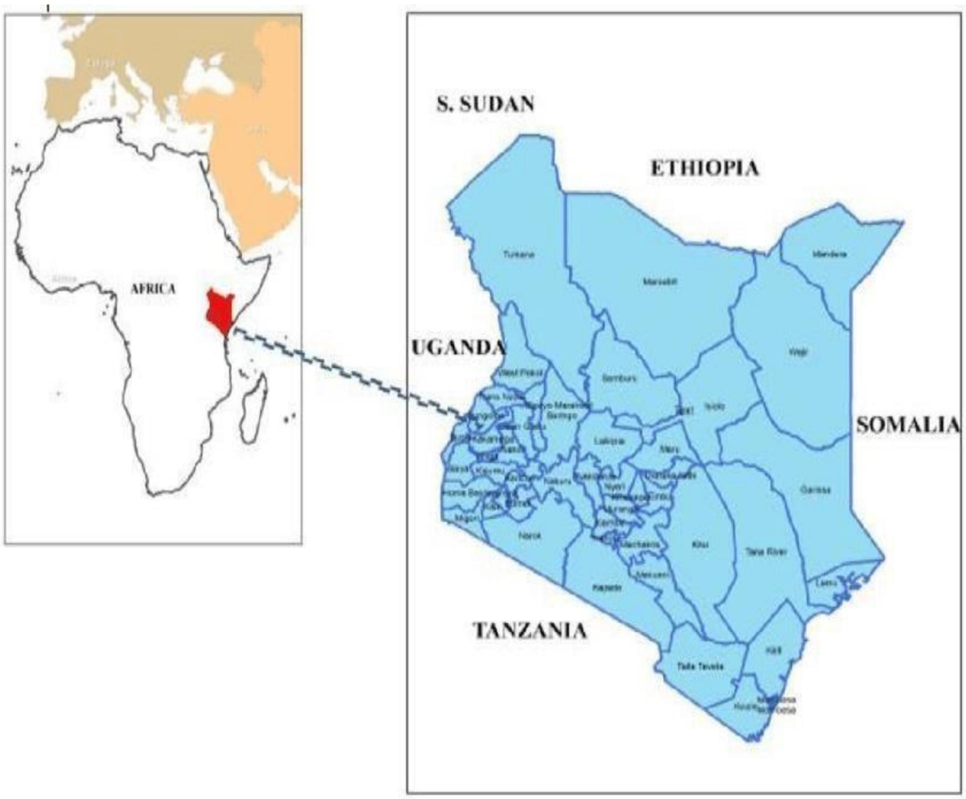

Figure 3.1: Map of Kenya showing the Study Area Source: Gündüz and Agayi (2021)

3.4 Target Population

The target population of this study comprised national-level annual macroeconomic and energy data for Kenya. Specifically, the population included: total primary energy consumption data for Kenya, Macroeconomic indicators comprising the study variable; economic growth, Inflation rate, interest rate, trade openness, and foreign direct investment inflows.

These variables were selected because they directly reflect domestic and external economic conditions that influence energy demand and consumption patterns. The study relied on secondary time-series data obtained from credible national and international institutions, including the World Bank, and KNBS.

3.5 Data Types and Sources

The study used secondary data from 1980 through 2024, using time series for the 45 observations. Secondary data was considered appropriate for this research owing to its methodological rigor, efficiency, and alignment with the study’s explanatory design. The use of existing datasets enables researchers to analyze large volumes of systematically collected information, often generated by reputable institutions, thereby enhancing the validity and generalizability of findings (Johnston, 2014). The study analyzed numerical indicators related to macroeconomic factors such as economic growth, inflation rate, interest rate, trade openness, foreign direct investment, and energy consumption statistics.

3.5.1 Time Series Data and its Properties

Time series data is a sequence of observations recorded over time at regular intervals, such as daily, monthly, or yearly and helps in understanding underlying patterns and behaviors, which can influence the model choices and forecasting techniques (Gujarati, 2004). The study analyzed annual data to understand how independent variables, including economic growth, interest rate, inflation rate, trade openness, and foreign direct investment, influence energy consumption.

3.5.2 Data Collection Instruments

The study employed data collection schedules for gathering information as shown in Appendix I. Data collection schedules are widely recognized for their ability to provide a systematic framework that ensures accuracy, consistency, and completeness of information across different time periods (Kothari, 2004). They minimize the risks of bias and omissions by standardizing the sequence and format of variables, thereby enhancing the reliability and comparability of data (Mugenda & Mugenda, 2003). In addition, schedules save time and improve efficiency by allowing researchers to capture large volumes of secondary data in an organized manner that is easy to analyze using statistical techniques (Cooper & Schindler, 2011).

3.6 Measurement of Study Variables

The evaluation of variables within this study determines relationship between economic elements and energy consumption in Kenya. The below table outlines the variables, their definitions, the measurement methods, the sources of data, and the expected sign. Table 3.1 below outlines the variables, their definitions, the measurement methods, the sources of data, and the expected sign.

Table 3.1 Data Source, Measurement and Description of Variables

Variable	Definition	Measurement	Data Source	Expected sign
Economic Growth (GDP)	Economic productivity per individual, reflecting economic well-being.	GDP per capita growth (annual %)	World Bank	+
Inflation Rate (INF)	The sustained increase in the general price level of goods and services in an economy	Consumer Price Index (annual %)	World Bank	-
Trade Openness (TOP)	The degree to which a country allows goods and services to be exchanged with other countries.	Trade (% of GDP)	KNBS	+
Interest Rate (RI)	The proportion of a loan charged as interest to the borrower	Real Interest Rate (Percentage)	World Bank	-
Foreign Direct Investment (FDI)	An ownership stake in a foreign company or project made by an investor, company, or government from another country	FDI Net Inflows (% of GDP)	World Bank	+
Energy Consumption (ENC)	Sum of all energy used over a specific period	Total Energy Consumption (kWh)	KNBS	Not defined (Dependent Variable)

3.6.1 Descriptive Analysis

Descriptive statistics are statistical techniques used to summarize, organize, and present the essential features of a dataset in a clear and meaningful way (Trochim, Donnelly, & Arora, 2016).

3.6.2 Inferential Data Analysis

Inferential analysis refers to a set of statistical techniques that allow researchers to generalize, predictions, or conclusions about a population based on information obtained from a sample or observed dataset.

3.7 Pre-Estimation Tests

Before applying the econometric models, the study conducted a series of pre-estimation tests to ensure that the data satisfied the underlying assumptions for reliable and valid inference.

These pre-estimation procedures ensured that the dataset was well prepared and that the chosen econometric models, particularly the ARDL approach, were appropriate for analyzing both the short and long-run dynamics of the relationship between energy consumption and macroeconomic variables.

3.7.1 Unit Root Test

The test was undertaken to determine whether the time series variables were stationary or non-stationary. The term stationarity indicates the circumstances in which the statistical properties of the data (e.g., its mean, variance, and autocorrelation) are not time-dependent, whereas non-stationary indicates that the statistical properties of the data is dynamic throughout the time and may be trend-driven, seasonal, or random walk. This was a significant move towards the study because most of the models used assume that the data will be stationary so that it will generate reliable and stable results at the standard significant levels (Dickey & Fuller, 1979).

Results indicated that some variables were stationary at level while others were stationary after first differencing suggesting integration orders. This warranted the use of cointegration based estimation techniques.

N/B: ARDL can be applied as it can accommodate both I (0) and I (1) variables if the all variables included in the study were stationary.

If a variable is identified as non-stationary, as described above by Lütkepohl and Schlaak (2018), the differencing would be done until it becomes stationary.

3.7.2 Cointegration Test

A cointegration test was conducted to identify any long-run relationships among non-stationary time series. The F-Bounds Test was used to tested long-run relationship (cointegration) between time series variables, even when the variables are a mix of stationary at level [I (0)] and first difference [I (1)], but not second difference [I (2)]. The F-statistic from the bounds test was compared with the critical lower and upper bound values to determine cointegration. When the computed F-statistic exceeded the upper bound critical value, the null hypothesis of no long-run relationship was rejected, confirming cointegration between variables. Conversely, an F-statistic below the lower bound indicated absence of a long-run relationship, while values falling between the bounds were considered inconclusive (Pesaran et al., 2001).

3.8 Model Specification

The foundational framework for analyzing the effect of macroeconomic variables on energy consumption was grounded in established energy-economy interaction theories, notably the Dependency Theory and the Energy Consumption Theory. These theories posit that economic variables such as inflation rate, interest rate, economic growth, foreign direct investment and trade openness directly influence energy demand through production needs, household consumption, and infrastructural expansion. Informed by the empirical studies of Sifuna (2019), Law & Sek (2022), and Omri *et al.* (2014), the study adopted the ARDL model to assess the influence of key macroeconomic indicators on Kenya's total energy consumption. The model incorporated variables such as economic growth, inflation rate, interest rate, trade openness, and foreign direct investment, which were theorized to impact energy consumption positively or negatively.

Accordingly, the study specified the functional relationship as follows:

ENC = f (GDP, INF, RI, TOP, FDI) ....(3.1)

Where:

ENC represents Energy Consumption

GDP represents Economic Growth

INF represents Inflation Rate

RI represents Interest Rate

TOP represents Trade Openness

FDI represents Foreign Direct Investment

This functional form is expressed in the general linear model below:

$$ENC_t = \beta_0 + \beta_1 GDP_t + \beta_2 INF_t + \beta_3 RI_t + \beta_4 TOP_t + \beta_5 FDI_t + \varepsilon t \ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

Where:

ENC_t represents the energy consumption at time t,

β_0 represents the intercept,

βi (for i=1,2,. .... ,5) represents independent variables coefficients at time t,

t denotes the period

εt represents the stochastic error term

This equation formed the basis for examining the dynamic and long-run relationships between macroeconomic factors and energy consumption in Kenya.

3.9 The Autoregressive Distributed Lag (ARDL)

The study used the Autoregressive Distributed Lag (ARDL) model to analyze short-term and long-term correlations between macroeconomic factors, including economic growth, interest rate, inflation rate, trade openness, foreign direct investment, and energy consumption patterns.

Pesaran, Shin, and Smith (2001) developed the autoregressive distribution lag (ARDL), which illustrates the direction of causality between variables. The ARDL approach has the advantage of employing a single simplified equation. Time-series data can benefit from the ARDL model, especially if the variables show varying orders of integration 1 (0), I (1), or a combination. The test of the current relationship between variables in levels will be relevant regardless whether regressors are purely 1 (0), purely 1 (1), or both, as no pretexting required for ARDL (Pesaran, Shin, & Smith,2001).

The representation of the general ARDL (p, q) model is:

$$\nabla Y_t = \alpha + \sum_{i=1}^{p}$$

$$\beta_i \Delta Y_{t-i} + \sum^{q}$$

$$\gamma_j \Delta X_{t-j} + \phi Y_{t-1} + \lambda X_{t-1} + \varepsilon_{jt=..0} \text{ .... } (3.3)$$

Where;

∇Y_t= The change in the dependent variable Y at time t.

α = alpha, the constant term (intercept).

β_i =The coefficient of the lagged difference of the dependent variable ΔY_{t-i}.

ΔY_{t-i}= The change in the lagged dependent variable.

p = The maximum lag length of the dependent variable.

Δ = Denotes the first difference, capturing short-run changes.

Φ = the coefficient that represents the speed of adjustment towards the long-run equilibrium. It indicates how quickly the dependent variable returns to its long-run equilibrium after a change.

Y_{t-1}= The lagged level of the dependent variable Y at time $t-1$, representing the long-run relationship for the dependent variable.

λ = The coefficient of the lagged level of the independent variable X_{t-1}

X_{t-1}= The lagged level of the independent variable X at time $t-1$ representing the long-run relationship for the independent variables.

ε_t= The error term at time t capturing the effects of all other factors that are not included in the model.

The F-Bounds testing methodology advanced by Pesaran and Shin (1998) and Pesaran, Shin, and Smith (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 various advantages: first, its use of regressors that are either I (0) or I (1), and second, its application of a single reduced form equation in the estimation of the long-run relationship within a context of system equation (Pesaran

& Shin, 1998). This was particularly important in this study, as it helped to determine whether energy consumption is influenced by the macroeconomic factors under consideration.

The specific model is as follows;

$ENC_t = \alpha + \Sigma(i = 1\ to\ p)\beta iENC_t(t - i) + \Sigma(j = 0\ to\ q)\delta jGDP_t(t - j) + \Sigma(i = 1\ to\ r)\beta iRI_t(t$

$-k) + \Sigma(k = 0\ to\ s)\theta k INF_t(t - l) + \Sigma(l = 0\ to\ t)\gamma l TOP_t(t - m) + \Sigma(m = 0\ to\ u)\lambda m FDI_t(t$

$-n) + \varepsilon_t$ .... *(3.4)*

Where:

ENC_t = Energy consumption (Dependent variable)

GDP_t = Economic Growth

Ri_t = Interest Rate

INF_t = Inflation Rate

TOP_t = Trade Openness

FDI_t = Foreign Direct Investment

α = Constant term

$\beta i, \delta j$ = Short run coefficients

$\theta k, \gamma l, \lambda m$ = Long run coefficients

p,q = Optimal lag orders determined by AIC/BIC criteria

ϵt = Error term

The F-Bounds testing methodology advanced by Pesaran and Shin (1998) and Pesaran, Shin, and Smith (2001) incorporates both I (0) and I (1) variables to investigate the long run relationship. The choice of lag length was crucial because too few lags omit essential information, and many lags resulted to overfitting and inefficiency. Lag length selection is the process of determining the optimal number of lagged values to include in a time series model, such as in Autoregressive (AR) models, Vector Autoregressive (VAR) models, or Error Correction Models (ECM) (Leites, Cerqueira, & Soares, 2024). Where variables are cointegrated, a dynamic unrestricted error correction model (UECM) will be extracted from the ARDL to integrate the short-run dynamics with the long-run equilibrium (equation

3.5) to help correct deviations from equilibrium in time series data.

$$\Delta InENCt = \alpha 1 + \Sigma\{\{ip=\}1\}\beta i\Delta InENC\{t-i\} + \Sigma\{\{jq=\}0\}\beta\{k\}\Delta InGDP\{t-j\} + \Sigma\{\{kr=0\}\}\beta\{l\}\Delta InRI\{t-k\} + \Sigma\{\{ls=\}\ 0\}\ \beta\{m\}\ \Delta InINF\{t-l\} + \Sigma\{\{mt\}=0\}\ \beta\{n\}\ \Delta InTOP\{t-m\}+\Sigma\{\{nu=\}0\}\beta\{o\}\Delta InFDI\{t-n\}+\epsilon 1t \ldots\ldots(3.5)$$

Where Δ is the first difference Operator, and ϵ_{1t} is the error term or disturbances.

Given the equation above, the F-Bounds procedure, using either the Standard Walt test or the F-statistic, was used to test for cointegration under the null hypothesis that no cointegration vector exists (i.e., βenc= βgdp = βinf =βri =βtop =βfdi= a= 0 against the alternative hypothesis (i.e., βenc≠ βgdp ≠ βinf ≠βri ≠βtop ≠ βfdi)

According to Pesaran, Shin, and Smith (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 cointegration relationship; it cannot be rejected if lower, thus indicating no cointegration, and the deduction would be inconclusive if it falls in between the F-Bounds. Hence, antecedent information on integration order would be needed in decision-making.

3.10 Post Estimation Diagnostic Tests

As Grajales (2013) noted, diagnostic tests test the validity and assumptions of the multiple regression model, ensuring the results are accurate and reliable before data analysis. The following tests were administered to test the hypotheses.

3.10.1 Normality Test

This study utilized a Normality Test to determine whether the residuals of the regression model follow a normal distribution. The normality is vital to statistical analyses, particularly hypothesis testing, to guarantee validity of significance testing and confidence limits. This test is used to test the assumption of normality of a lot of regression-based models. This was done using Jarque-Bra test. If;

H_0: JB = 0 (normally distributed)

H_1: JB $\neq$ 0 (not normally distributed)

3.10.2 Heteroscedasticity Test

The heteroscedasticity test was used to evaluate how well the residual variance remained consistent across different levels of the independent variables. The fluctuations of error variance between observations in heteroscedasticity create inefficient estimates that undermine the reliability of regression analysis. Correct identification and solution of this problem is essential for achieving reliable and precise statistical outcomes. The Breusch and Pagan Test (1979), the Lagrange Multiplier (LM) test, and White's Test (1980) were used for this purpose. These tests are based on the residuals from OLS regressions. If heteroscedasticity is detected, robust standard errors are used to correct the issue and ensure reliable parameter estimates.

3.10.3 Multicollinearity Test

The multicollinearity test determined the relationship between independent variables. The correlation between two or more independent variables becomes excessive in multicollinearity, which produces unpredictable regression coefficients. To examine this correlation, the Variance Inflation Factor (VIF) determined its severity. The test was first introduced by Marquardt (1970) in his work on multicollinearity diagnostics.

The VIF for each predictor variable Xi is expressed as;

$$VIF_i = \frac{1}{1-R_i^2} \quad \text{...........} \quad (3.6)$$

where: R_i^2 = coefficient of determination obtained by regressing variable X_i on all other independent variables.

High multicollinearity exists when VIF values exceed 10, causing the model to become less reliable and accurate and requiring corrective measures (such as variable transformation, removal, or the use of alternative estimation techniques). VIF values below 10 indicated the absence of serious multicollinearity among explanatory variables (Wooldridge, 2016).

3.10.4 Serial Correlation Test

This study conducted a serial correlation test to check if the residuals from the regression model are correlated over time. Serial correlation occurs when residual values are correlated, leading to inaccurate estimates and potentially improper conclusions. The research examined this problem using the Durbin-Watson d test and the Breusch-Godfrey tests, which improve the validity and reliability of the analysis.

a) Durbin–Watson Test

The Durbin–Watson (DW) statistic was introduced by James Durbin and Geoffrey Watson in their seminal paper (Durbin & Watson, 1951)

The Durbin–Watson test statistic is expressed as:

$$DW = \sum_{t=2}^{n} (e_t - e_{t-1})^2$$

$\sum^{n} t{=}1\ e\_t^2$.. *(3.7)*

Where:

e_t = residual at time t

n = number of observations the decision rule is;

$DW = 2$: no autocorrelation

$DW < 2$: positive autocorrelation

$DW > 2$: negative autocorrelation

b) Breusch–Godfrey Test

The Breusch–Godfrey test extends the Durbin–Watson test to higher-order autocorrelation. It comes from the work of Trevor S. Breusch and Adrian R. Pagan, who formalized the LM test approach in econometrics (Breusch & Pagan, 1980).

It involves regressing the residuals on the original regressors plus their lagged values, and computing the test statistic as:

$LM = nR^2$………………………………………………………………………………………*(3.8)*

where:

n= number of observations

R^2= coefficient of determination from the auxiliary regression of residuals on lagged residuals and explanatory variables

The hypotheses are:

H_0: No serial correlation

H_1: Presence of serial correlation

If the computed LM statistic exceeds the critical value from the χ^2 distribution (with degrees of freedom equal to the number of lags), the null hypothesis is rejected, indicating the presence of serial correlation.

3.10.5 Stability Test

A Stability Test was conducted to assess whether the estimated parameters remain consistent over time. This is important in ensuring the reliability and confirming that the model does not change significantly during different periods. The Cumulative Sum of Squares (CUSUMSQ) test, introduced by Brown, Durbin, and Evans (1975), was used to assess the stability of regression coefficients over time. This is superior to the Ramsey test, as the CUSUMSQ test relies on the cumulative sum of recursive residuals, allowing it to continuously monitor the stability of model parameters across the sample.

$CUSUMSQ_t = \frac{}{\delta} \sum_{i=1} {}^{i}2, \quad t = 1,2,..T$ ....(3.9)

Where: U_i = recursive residuals

δ^2 = standard deviation of residuals

T= total number of observations

Hypotheses for Stability Test:

H_0: The model is stable (parameters are constant over time)

H_1: The model is unstable (parameters change over time).

Graphically, stability is confirmed if the CUSUMSQ statistic stays within the 5% significance bounds.

Table 3.2: Hypothesis Testing

Hypothesis	p-value	Decision Rule
Economic growth has no significant effect on energy consumption in Kenya.	$p \leq 0.05$	Reject the null hypothesis
Inflation has no significant effect on energy consumption in Kenya	$p \leq 0.05$	Reject the null hypothesis
Interest rate has no significant effect on energy consumption in Kenya	$p \leq 0.05$	Reject the null hypothesis
Trade openness has no significant effect on energy consumption in Kenya.	$p \leq 0.05$	Reject the null hypothesis
Foreign direct investment has no significant effect on energy consumption in Kenya.	$p \leq 0.05$	Reject the null hypothesis

Table 3.2 above presents the study hypotheses alongside the decision rules applied in hypothesis testing. The table outlined the null hypotheses regarding the effects of economic growth, inflation rate, interest rates, trade openness, and foreign direct investment on energy consumption in Kenya. It also specified the threshold for statistical significance ($p \leq 0.05$), which served as the decision rule for accepting or rejecting each hypothesis.

3.11 Ethical Consideration

The study strictly adhered to data reliability and accuracy by using verified sources, and proper citations and acknowledgments was made for all secondary data sources. The study also aligned with the ethics guidelines set by the National Commission for Science, Technology, and Innovation (NACOSTI). Before data collection, authorization was obtained from NACOSTI, and an official approval letter from the university was issued, permitting the study to comply with regulatory requirements. These approvals ensured that the research adhered to ethical standards and legal frameworks, guaranteeing data collection and analysis integrity.

CHAPTER FOUR

RESULTS

4.1 Introduction

This section presents the study findings. It includes the introduction, descriptive statistics results, correlation analysis, pre-estimation tests, the results of the Autoregressive distributed lags model, diagnostic test results, and post-estimation diagnostic checks.

4.2 Descriptive Statistics

The descriptive statistics are summarized using measures of central tendency (mean, minimum, and maximum) and dispersion (standard deviation) to provide a clear overview of the data distribution.

4.2.1 Summary of Descriptive Statistics

Table 4.1 presents summary statistics on the key macroeconomic indicators for Kenya covering the period 1980 to 2024.

The study variables were Energy Consumption (ENC), Economic Growth (GDP), Foreign Direct Investment (FDI), Inflation Rate (INF), Interest Rate (RI), and Trade Openness (TOP).

Table 4.1: Summary of Descriptive Statistics

Variable	**Obs.**	**Mean**	**Std. deviation**	**Minimum**	**Maximum**
ENC	45	477.5642	34.5308	434.5218	544.6186
GDP	45	3.8444	2.2285	-.8000	8.1000
FDI	45	.6935	.7199	-.0053	3.0947
INF	45	11.1933	8.2275	1.6000	46.0000
RI	45	7.1560	6.4889	-10.0960	21.0963
TOP	45	50.9628	11.4958	27.2400	72.8600

Notes: Obs denotes the number of observations, ENC *–Energy Consumption measured by the Total Energy Consumption,* GDP *– GDP Per capita Growth (annual %), FDI –Net Inflows (% of GDP), INF-CPI (annual %), RI-Interest Rate (%) and TOP- Trade (% of GDP).*

Table 4.1 above shows the descriptive statistics, which reveal that energy consumption in Kenya averaged 477.56 with a standard deviation of 34.53, indicating moderate variability. The lowest recorded consumption was 434.52 kWh, while the highest reached 544.62 kWh. Economic growth, measured by the annual change in GDP per capita growth, had a mean of 3.84%, ranging from - 0.8% to 8.1%, with a standard deviation of 2.23%, suggesting noticeable volatility.

Foreign Direct Investment (FDI), measured by Net inflows expressed as a percentage of GDP, had a mean value of 0.69%, with a standard deviation of 0.72%. The minimum value was negative at -0.005%, and the maximum reached 3.09%, representing periods of both low and high foreign investment inflows. Inflation averaged 11.19% and showed significant fluctuations, as revealed by a high standard deviation of 8.23%. The inflation rate varied widely from a low of 1.6% to a peak of 46%.

The interest rate had a mean of 7.16% and a standard deviation of 6.49%. The lowest value was - 10.10%, while the highest was 21.10%. Trade openness, measured by the ratio of exports and imports to GDP, averaged 50.96%, with a standard deviation of 11.50%. The openness ratio ranged from 27.24% to 72.86%, showing variation in Kenya's level of integration into global trade over the study period.

Figure 4.1: Plots of variables at level

Figure 4.2: Plots of variables at First Difference

Figure 4.1 presents the time series plots of the study variables, namely Energy Consumption (ENC), Economic Growth (GDP), Foreign Direct Investment (FDI), Inflation

Rate (INF), Interest Rate (RI), and Trade Openness (TOP). These visualizations help to highlight the underlying dynamics, trends, and fluctuations in the variables across the study period, providing initial insights before conducting further econometric analysis.

Energy Consumption (ENC) shows a clear upward trend throughout the period under review. From the early 1980s, consumption was relatively lower and fluctuated within a narrow band, but from around 2005 onwards, a sharp and sustained rise is evident. This persistent increase reflects the energy increase need associated with economic activities, industrialization, and population growth. The surge post-2005 may also be linked to structural changes in the economy, such as industrial expansion and higher urbanization rates, which placed additional pressure on energy resources.

Economic Growth (GDP), on the other hand, demonstrated considerable fluctuations without a well-defined long-term trend. Periods of strong positive growth are interspersed with contractions, reflecting the cyclical economic nature and influence of both domestic and external shocks. The volatility of GDP growth underscores the challenges of achieving sustained economic expansion in the presence of factors such as political instability, global financial crises, and policy transitions. The absence of a stable trend suggests that growth was often reactive to shocks rather than the result of steady structural transformation.

Foreign Direct Investment (FDI) appeared highly irregular, with significant spikes and troughs across the study period. Notably, there are two structural breaks: one in the early years of the series and another close to the end of the period. These could represent changes in investment policy, global capital flows, or domestic conditions that alternately encouraged or discouraged foreign investors. The pronounced volatility in FDI inflows implied that the investment environment has been unstable, possibly shaped by both global economic cycles and domestic institutional or political uncertainties.

Inflation Rate (INF) is one of the most volatile variables in the dataset. The plot shows repeated and sharp spikes, particularly in the 1990s and again during the late 2000s. Such patterns indicate episodes of economic instability, linked to monetary and fiscal policy mismanagement, exchange rate pressures, or supply-side shocks such as food and fuel crises. The high degree of fluctuation makes inflation a critical macroeconomic challenge since persistent volatility undermines price stability, erodes purchasing power, and creates uncertainty for investors and consumers.

Interest Rate (RI) also oscillates considerably around its mean, with two particularly sharp spikes evident during the study period. These sudden increases likely reflect episodes of monetary tightening intended to control runaway inflation or stabilize the currency. However, high-interest rate volatility can discourage borrowing, reduce investment, and create financial uncertainty.

Trade Openness (TOP) reveals a general downward trajectory over time. In the early years, openness was relatively high, but a consistent decline is evident toward the later years of the study. This suggests a gradual reduction in the country's integration with the global economy, which could result from protectionist trade policies, weakening export performance, or increased reliance on domestic markets. A shrinking level of trade openness raises concerns about missed opportunities for international competitiveness and growth spillovers from global trade.

Figure 4.2 presents the time series plots of the first differences of Energy Consumption (ENC), Economic Growth (GDP), Foreign Direct Investment (FDI), Inflation Rate (INF), Interest Rate (RI), and Trade Openness (TOP). Economic Growth (GDP, D) appears relatively more stable compared to other differenced series, though it still exhibits noticeable oscillations.

4.2.2 Correlation Analysis

Correlation analysis was conducted to examine the strength and direction of the relationships among the study variables. The results of the correlation analysis are presented in Table 4.2. All the correlation coefficients were statistically tested at the 5% level of significance.

Table 4.2: Correlation Matrix

	ENC	GDP	FDI	INF	RI	TOP
ENC	1.0000					
GDP	0.2990*	1.0000				
FDI	0.0663	0.1526	1.0000			
INF	-0.3447*	-0.4454*	0.1614	1.0000		
RI	-0.0186	-0.0937	-0.0880	-0.2848	1.0000	
TOP	-0.8624*	-0.1908	0.0568	0.5131*	-0.0328	1.0000

Note: Values with asterisks are significant at the 5 percent level

Table 4.2 presents the correlation coefficients among the study variables, providing insights into the strength and direction of their pairwise associations. Each variable shows a perfect correlation with itself along the diagonal of the table, with a value of 1.0000. The off-diagonal elements capture relationships across variables; some are statistically significant at the 5% level, while others are weak and insignificant.

4.2.3 Economic Growth and Energy Consumption

The correlation analysis indicates a positive and statistically significant association between economic growth (GDP) and energy consumption (ENC), with a coefficient of 0.2990 at the 5 percent significance level. This suggests that higher levels of GDP are moderately linked to increased energy consumption. The implication is that as the Kenyan economy expands, demand for energy rises in order to sustain industrial production, transportation, and household activities. This finding aligns with the energy ladder hypothesis, which postulates that economic development is typically accompanied by rising energy needs as households and firms shift toward modern and energy-intensive production and consumption patterns. Although the magnitude of the relationship is moderate, its statistical significance underscores the critical role of energy in shaping Kenya's growth trajectory, underscoring energy as both a driver and a consequence of economic development.

4.2.4 Inflation Rate and Energy Consumption

The results reveal a negative and statistically significant correlation between inflation (INF) and energy consumption (ENC), with a coefficient of −0.3447 ($p < 0.05$). This relationship suggests that periods of high inflation are associated with reduced energy use in Kenya. Inflation diminishes purchasing power, raises the cost of energy products, and discourages consumption and investment in energy-intensive sectors. Households may adjust their budgets by cutting back on energy expenditures, while firms may scale down energy use to contain operational costs. This negative association is consistent with macroeconomic theory, which posits that inflationary pressures often impose contractionary effects on economic activities. The results highlight the vulnerability of energy consumption to price instability and underscore the importance of maintaining macroeconomic stability as a means of safeguarding energy demand.

4.2.5 Interest Rate and Energy Consumption

The correlation coefficient between interest rate (RI) and energy consumption (ENC) is −0.0186, which is both weak and statistically insignificant. This implies that fluctuations in real interest rates had little direct effect on energy consumption in Kenya during the study period. A possible explanation is that the transmission mechanism of monetary policy through interest rates may have been weak due to structural constraints in the financial system, limited access to credit, or the dominance of informal financing mechanisms. Consequently, variations in interest rates may not have significantly altered investment or consumption behaviors, including energy demand. This finding suggests that other macroeconomic factors, such as fiscal policy, external shocks, or structural bottlenecks, were likely more influential in shaping energy consumption patterns than monetary policy instruments.

4.2.6 Trade Openness and Energy Consumption

A strong negative and statistically significant correlation was observed between trade openness (TOP) and energy consumption (ENC), with a coefficient of −0.8624 ($p < 0.05$). This indicates that greater integration into international trade is associated with reduced domestic energy consumption. This shows that trade openness encourages efficiency gains and technological improvements that reduce reliance on domestic energy. Furthermore, openness may shift the economic structure from energy-intensive industries toward service-oriented or technology-based sectors that consume relatively less energy. This outcome resonates with the structural transformation theory, which argues that economies undergoing globalization often transition to sectors with lower energy dependence. While trade openness enhances competitiveness and market access, it may simultaneously reduce energy consumption by altering the composition of production and consumption activities in Kenya.

4.2.7 Foreign Direct Investment and Energy Consumption

The relationship between foreign direct investment (FDI) and energy consumption (ENC) is weak and statistically insignificant, with a correlation coefficient of 0.0663. This suggests that FDI inflows did not exert a significant influence on energy consumption patterns in Kenya during the study period. One likely explanation is that much of the FDI may have been concentrated in sectors with minimal spillover effects on domestic energy use, such as extractive industries or capital-intensive enclaves. Such investments, while boosting certain sectors, may not generate broad-based impacts on energy demand. This finding highlights the need for policies that channel FDI into productive sectors with stronger linkages to the wider economy, such as manufacturing and infrastructure, where energy consumption plays a pivotal role in driving productivity and growth.

4.3 Unit Root Tests without Structural Breaks

In this study, the stationarity properties of the time series data were examined prior to estimating the Autoregressive Distributed Lag (ARDL) model. The presence of unit roots can affect the validity of regression results. According to Budiono and Purba (2022), a time series that exhibits a unit root is considered non-stationary, meaning its mean and variance change over time. In contrast, a stationary series has a constant mean and variance. To ensure reliable estimation, unit root tests were conducted on each of the variables: energy consumption (ENC), gross domestic product growth (GDP), foreign direct investment (FDI), inflation Rate (INF), interest rate (RI), and trade openness (TOP).

Two standard unit root tests, the ADF test (Dickey & Fuller, 1979) and the PP test (Phillips & Perron, 1988), were employed at both level and first difference forms of each variable. Variables found to be non-stationary at level were differenced until they exhibited stationarity. To further account for potential structural breaks that may affect macroeconomic variables stationarity (such as policy changes or external shocks), the Clemente-Montañés-Reyes (CMR) unit root test with a single mean shift (Clemente *et al.*, 1998) was applied. This approach enhances the robustness of the unit root testing procedure by capturing structural changes that may bias traditional tests.

4.3.1 Augmented Dickey Fuller Unit Root Test

The Augmented Dickey-Fuller (ADF) unit root test was employed to assess the stationarity of the time series variables used in this study. Estimating relationships using non-stationary data can lead to spurious regression results, and thus it is crucial to test for unit roots before model estimation (Gujarati, 2004). The ADF test improves on the basic Dickey-Fuller test by accounting for higher-order serial correlation through the inclusion of lagged difference terms. It tests the null hypothesis that a unit root is present (i.e., the series is non-stationary) against the alternative of stationarity. If the p-value from the test is greater than 0.05, the null hypothesis cannot be rejected, indicating non-stationarity. The ADF unit root test was conducted at both the level and first difference to determine the stationarity of the variables used in the study: Energy Consumption (ENC), economic growth (GDP), foreign direct investment (FDI), Inflation Rate (INF), Interest Rate (RI), and Trade Openness (TOP).

Table 4.3: Augmented Dickey- Fuller Unit Root Test at Level and at First Difference

Unit Root Test at Level						
				Critical Values		
Variables	Mackinno p-values	Test Statistic	1%	5%	10%	*Remark*
ENC	0.9614	0.089918	-3.588509	-2.929734	-2.603064	*Unit root*
GDP	0.0003	-4.772873	-3.588509	-2.929734	-2.603064	*Stationary*
FDI	0.0001	-5.157377	-3.588509	-2.929734	-2.603064	*Stationary*
INF	0.0109	-3.555991	-3.588509	-2.929734	-2.603064	*Stationary*
RI	0.0004	-4.723847	-3.588509	-2.929734	-2.603064	*Stationary*
TOP	0.5608	-1.426434	-3.588509	-2.929734	-2.603064	*Unit root*
Unit Root at First Difference						
ENC	0.0002	-4.929820	-3.592462	- 2.931404	-2.603944	*Stationary*
GDP	0.0000	-6.839174	-3.592462	- 2.931404	-2.603944	*Stationary*
FDI	0.0000	-7.098430	-3.592462	- 2.931404	-2.603944	*Stationary*
INF	0.0000	-7.267366	-3.592462	- 2.931404	-2.603944	*Stationary*
RI	0.0000	-8.560348	-3.592462	- 2.931404	-2.603944	*Stationary*
TOP	0.0000	-6.907248	-3.592462	- 2.931404	-2.603944	*Stationary*

Source: Author's Compilation from STATA Output, 2025

The Augmented Dickey-Fuller (ADF) unit root test was applied at both level and first difference to assess the stationarity properties of the study variables, namely Energy Consumption (ENC), Economic Growth (GDP), Foreign Direct Investment (FDI), Inflation Rate (INF), Real Interest Rate (RI), and Trade Openness (TOP). Establishing the order of integration is a critical prerequisite in time series analysis because the presence of non-stationary variables can lead to spurious regression results, where relationships appear significant purely due to shared trends rather than true economic linkages (Gujarati, 2004).

At the level form, the results presented in Table 4.3 reveal a mixed pattern of stationarity. Energy Consumption (ENC) and Trade Openness (TOP) had MacKinnon p-values of 0.9614 and 0.5608, respectively, which are greater than the 5% significance threshold. Furthermore, their test statistics (0.089918 for ENC and -1.426434 for TOP) were less negative than the critical values at the 1%, 5%, and 10% significance levels. This implies that the null hypothesis of a unit root could not be rejected, confirming that both ENC and TOP were non-stationary at level. The non-stationarity of ENC may be attributed to long-term upward or downward consumption trends influenced by demographic shifts, technological adoption, and policy changes, while the persistence of unit root in TOP could reflect the gradual and policy-driven nature of trade liberalization.

In contrast, GDP, FDI, INF, and RI were found to be stationary at level, with p-values below 0.05 and test statistics more negative than the critical values. For example, GDP reported a p-value of 0.0003 and a test statistic of -4.772873, well beyond the critical values, indicating rejection of the null hypothesis of a unit root. Similarly, FDI (-5.157377), INF (-3.555991), and RI (-4.723847) all surpassed the threshold, suggesting that these series do not exhibit stochastic trends and are instead mean-reverting. This stationarity is consistent with the notion that GDP, FDI inflows, inflation, and interest rates are more responsive to short-run shocks and policy interventions, thereby stabilizing around long-term equilibrium values.

After applying first differencing, all variables became stationary, as reflected by p-values below 0.05 and test statistics more negative than the corresponding critical values. For instance, ENC recorded a test statistic of -4.929820 with a p-value of 0.0002, confirming its stationarity after differencing. Similarly, TOP, which was initially non-stationary, became stationary after differencing with a test statistic of -6.907248. This outcome indicates that both ENC and TOP are integrated of order one, I (1), while GDP, FDI, INF, and RI are integrated of order zero, I (0).

4.3.2 Philips – Perron Test for Unit Root Test

To complement the Augmented Dickey-Fuller test and enhance the robustness of unit root diagnostics, the Phillips-Perron (PP) test was also applied to examine the stationarity properties of the study variables. The PP test, developed by Phillips and Perron (1988), modifies the Dickey-Fuller procedure to allow for heteroskedasticity and serial correlation in the error terms without adding lagged difference terms. This makes it particularly useful in dealing with time series data that exhibit autocorrelation or changing variance over time, as is common in macroeconomic variables. In this study, the PP test was conducted for each of the variables Energy Consumption (ENC), Economic Growth (GDP), Foreign Direct Investment (FDI), Inflation Rate (INF), Interest Rate (RI) and Trade Openness (TOP) at both level and first difference.

The Phillips-Perron (PP) test was applied to validate the stationarity properties of the variables under study: Energy Consumption (ENC), economic growth (GDP), foreign direct investment (FDI), Inflation Rate (INF), Interest Rate (RI), and Trade Openness. This test evaluates if thenull hypothesis contains a unit root against stationarity alternative.

Table 4.4: Philips – Perron Test for Unit Root at Level and at First Difference

Unit Root Test at Level						
			Critical Values			
Variables	Mackinnon p-values	Test Statistic	1%	5%	10%	*Remark*
ENC	0.9389	-0.135649	-3.588509	-2.929734	-2.603064	*Unit root*
GDP	0.0003	-4.788643	-3.588509	-2.929734	-2.603064	*Stationary*
FDI	0.0001	-5.157377	-3.588509	-2.929734	-2.603064	*Stationary*
INF	0.0126	-3.498444	-3.588509	-2.929734	-2.603064	*Stationary*
RI	0.0002	-4.870979	-3.588509	-2.929734	-2.603064	*Stationary*
TOP	0.5608	-1.412971	-3.588509	-2.929734	-2.603064	*Unit root*
Unit Root at First Difference						
ENC	0.0003	-4.823521	-3.592462	-2.931404	-2.603944	*Stationary*
GDP	0.0001	-18.58614	-3.592462	-2.931404	-2.603944	*Stationary*
FDI	0.0001	-22.95341	-3.592462	-2.931404	-2.603944	*Stationary*
INF	0.0000	-8.684967	-3.592462	-2.931404	-2.603944	*Stationary*
RI	0.0000	-10.71983	-3.592462	-2.931404	-2.603944	*Stationary*
TOP	0.0000	-7.110923	-3.592462	- 2.931404	-2.603944	*Stationary*

The results of the Philips–Perron unit root test as presented in Table 4.4 reveal important insights into the time-series properties of the variables under study.

GDP recorded a p-value of 0.0003 and a test statistic (−4.7886) that is more negative than the 1% critical value, thereby rejecting the null hypothesis and confirming stationarity. The results for FDI were consistent with this, as evidenced by a p-value of 0.0001 and a test statistic of −5.1574, which is more negative than the critical values at all conventional significance levels. Inflation also proved to be stationary at level with a p-value of 0.0126 and a test statistic of −3.4984, which exceeded the 5% and 10% critical values. Similarly, interest rate was stationary at level, with a p-value of 0.0002 and a test statistic (−4.8709) that comfortably surpassed the critical values. Collectively, these findings imply that GDP, FDI, INF, and RI are integrated of order zero, I (0), while ENC and TOP contain a unit root at level.

Once first differencing was applied, all variables, including ENC and TOP, became stationary. ENC, which was previously non-stationary, recorded a highly significant p-value of 0.0003 and a test statistic (−4.8235) that was more negative than the critical values. TOP also turned stationary at first difference, as indicated by a p-value of 0.0000 and a test statistic of −7.1109. The already stationary variables GDP, FDI, INF, and RI remained strongly stationary at first difference, with highly significant p-values and large negative test statistics far below the critical values. These results imply that while GDP, FDI, INF, and RI are stationary at level, ENC and TOP are stationary only after first differencing. Hence, the dataset comprises a combination of I (0) and I (1) variables.

4.4 Unit Root Test with Structural Breaks

Following the conventional unit root tests, it was necessary to account for the possibility of structural breaks within the time series data. According to Baum and Hurn (2021), traditional tests such as the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) may produce biased results when structural changes are present in the series, as they do not accommodate sudden shifts in mean or trend. These structural changes could stem from major economic reforms, policy shifts, or external shocks, all of which are relevant in the Kenyan macroeconomic context. To address this limitation, the study employed the Clemente-Montañés-Reyes (CMR) unit root test with a single mean shift, under the Additive Outlier (AO) model, which is appropriate when a structural break affects the series instantaneously.

4.4.1 Clemente-Montañés-Reyes Unit-root Test with Single Mean shift, AO model

To strengthen the accuracy of stationarity testing incorporating structural changes in the economy, this study employed the Clemente-Montañés-Reyes (CMR) unit root test using the Additive Outlier (AO) model with a single mean shift. This model is appropriate when a variable is likely to experience a sudden shock, such as a policy change, economic crisis, or major external event that affects the series immediately. The CMR test improves upon traditional unit root tests by allowing for such structural breaks, which, if ignored, could lead to misleading conclusions about the nature of the data (Balcilar *et al*., 2022).

The null hypothesis of the test assumes the presence of a unit root, even in the presence of a structural break. A test statistic exceeding the critical value indicates that the series is stationary with a structural break. Figure 4.3 presents the graphical results of the CMR test for each variable used in the study: energy consumption (ENC), GDP growth, FDI, inflation rate, interest rate, and trade openness. These graphs visually capture key historical shifts in Kenya's macroeconomic environment, such as changes in policy regimes or external shocks, which may have contributed to structural breaks in the data. Visualizing these breaks helps to contextualize the timing and impact of such events on the macroeconomic series.

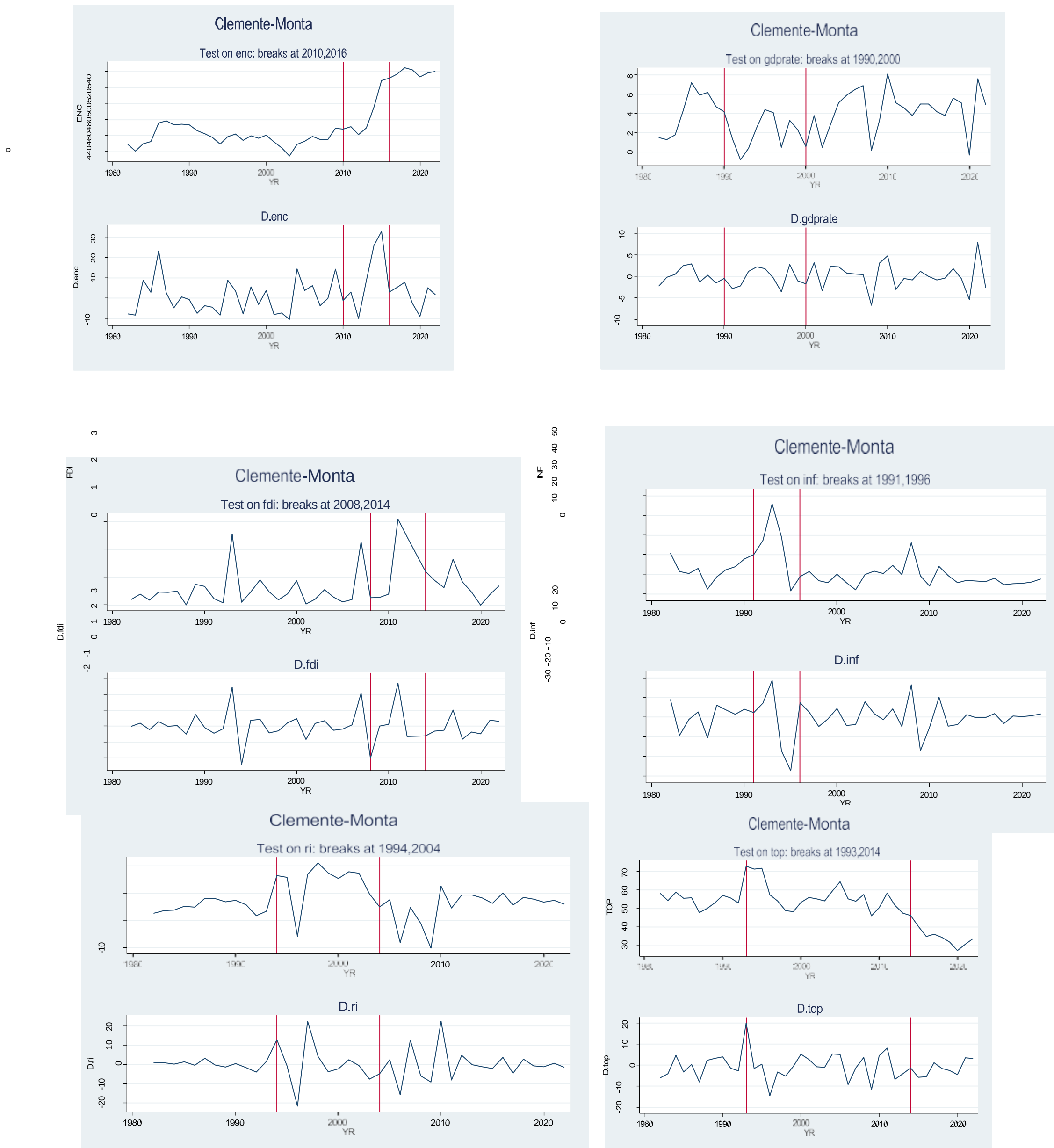

Figure 4.3: Plots of Clemente-Montañés-Reyes Unit-root Test with Single Mean, AO

The test results are consistent with the findings in Table 4.5, which also reports outcomes from the CMR Double Innovative Outlier test.

Table 4.5: Results of Clemente-Montañés-Reyes Double Innovative Outlier Test for Unit Root

Variable	Breaks	Coef	T-Statistic	Rho-1	P-Value	Year	Remark
ENC	DU1	34.50200	5.545	-5.916	0.000	2010	Structural break
	DU2	47.40452	4.519	-5.490	0.000	2016	Structural break
GDP	DU1	-2.34727	-2.683	-5.615	0.011	1990	Structural break
	DU2	2.60750	-2.042	-5.490	0.001	2000	Structural break
RI	DU1	7.72808	3.277	-2.480	0.004	1994	Structural break
	DU2	-7.52582	-3.364	-5.490	0.003	2004	Structural break
TOP	DU1	-1.96500	-0.897	-4.246	0.375	1993	No Structural break
	DU2	- 2.13943	-9.072	-5.490	0.000	2014	Structural break
FDI	DU1	1.01687	3.496	-1.00211	0.001	2008	Structural break
	DU2	-0.84886	-2.535	-5.601	0.015	2014	Structural break
INF	DU1	9.52000	6.518	-1.91511	0.05	1991	Structural break
	DU2	- 4.12357	6.304	-3.336	0.009	1996	Structural break

Note: DU represent time structural break

The results from Table 4.5 and Figure 4.3 indicate two significant structural breaks in energy consumption in 2010 and 2016. The 2010 break coincides with Kenya's efforts to diversify its energy mix and increase investment in renewable energy under Vision 2030, including the development of the Geothermal Development Company (GDC) and wind power initiatives (GOK, 2007). This marked a shift in energy consumption patterns from reliance on fossil fuels to increased uptake of geothermal and wind sources. The 2016 break reflects the impact of large-scale infrastructure projects such as the commissioning of the Lake Turkana Wind Power project and the ongoing implementation of the Last Mile Connectivity Project, which rapidly expanded access to electricity across rural areas (World Bank, 1985).

For GDP, structural breaks are observed in 1990 and 2000. The 1990 break corresponds to the onset of economic stagnation and the structural adjustment programs (SAPs) imposed by the IMF and World Bank, which significantly altered public investment and fiscal policies (Kibabu, 2018). The 2000 break is associated with the recovery period following the economic downturn of the 1990s, coupled with the introduction of reforms in the banking sector and increased donor support, which helped stimulate growth leading up to the early 2000s (World Bank, 2001).

Trade Openness showed one significant structural break in 2014, while the 1993 break was not statistically significant. This break in 2014 aligns with Kenya's developing regional trade under the East African Community (EAC) Common Market Protocol, as well as with its growing ties with China and other emerging economies. In that year, a number of trade facilitation policies and improvements were also implemented at critical infrastructure locations like Mombasa Port, with notable effects on trade flows (World Bank, 2016). This 1993 period, although not statistically significant in this test, coincided with the period of trade liberalisation (SAPs, exchange rate unification, tariff changes etc.).

There were 2008 and 2014 registered FDI breaks. The 2008 break aligns with increased investor interest following the end of the post-election crisis and the adoption of pro-investment policies of tax incentives and the establishment of Special Economic Zones (SEZs) (UNCTAD, 2009).

4.5 Optimum Lag Length Determination

In time series econometrics, determining the optimal lag length is a critical step before estimating models such as ARDL, VAR, or VECM. The choice of lag length significantly affects the explanatory power and validity of model results. Too few lags may omit relevant dynamics, leading to biased estimates, while too many lags can cause overfitting, reduce degrees of freedom, and increase multicollinearity. To address this, Table 4.6 reports lag selection based on formal information criteria, namely, the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC), and Hannan–Quinn Information Criterion (HQIC). FPE and AIC are better suited for moderate-sized samples ($n < 60$), whereas HQIC and SBIC are more reliable with larger datasets ($n > 120$). The selection process also included likelihood ratio (LR) tests to ensure robustness. Selecting an appropriate lag length enhances model efficiency and mitigates the risks of misspecification due to over-fitting (Liew, 2021). Given that this study spans the period 1980–2024, the relatively large sample size justifies reliance on AIC and FPE.

Table 4.6: Selection of Optimum Lag Criteria

Selection -order criteria

Sample 1980-2024 Number of Obs = 41

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-727.247				1.4e+08	35.7682	35.8595	36.0189
1	-630.527	193.44	36	0.000	7.3e+06*	32.8062	33.4454*	34.5616*
2	-593.665	92.248*	36	0.000	7.8e+06	32.237*	33.9513	36.0241

The optimal lag length for the ARDL model was determined using the Akaike Information Criterion (AIC), which minimizes information loss while balancing model fit and complexity. As shown in Table 4.6, the AIC reached its lowest value at lag 2 (AIC = 32.237), which means that this is the most suitable lag for the analysis. Although other criteria, such as FPE, suggested shorter lag lengths (lag 1), the study prioritizes AIC due to its ability to capture the dynamics of macroeconomic time series more flexibly, especially in moderate-sized samples (n < 60) (Liew, 2021).

4.6 F-Bounds Test for Cointegration

The F-Bounds Testing approach has become a widely utilized econometric technique for investigating long-run relationships among macroeconomic variables. Unlike traditional cointegration tests such as Engle-Granger or Johansen, which require all variables to be integrated of the same order, the F-Bounds Test is particularly attractive because it accommodates a mixture of I (0) and I(1) variables. This feature makes it ideal for empirical work involving economic data series that exhibit different orders of integration, a common scenario in developing economies where data irregularities are prevalent (Kadioglu, Turan, & Gurbuz, 2025).

According to Natsiopoulos and Tzeremes (2022), the F-Bounds Test is embedded in the Autoregressive Distributed Lag (ARDL) framework, which allows for the simultaneous estimation of both short-run dynamics and long-run equilibrium relationships. The method involves estimating an unrestricted error correction model (UECM) and conducting an F-test to determine whether a stable long-run relationship exists between the dependent variable and its regressors. If the computed F-statistic exceeds the upper bound critical value, the null hypothesis of no cointegration is rejected.

The practicality of the F-Bounds Test has been emphasized in applied economic literature, particularly in the context of small sample sizes and developing country datasets. Thuy and Thuy (2019) highlight the test's suitability for short time series, noting that the ARDL-based F-Bounds approach is robust even when the sample size is limited. This characteristic is particularly relevant for studies in Sub-Saharan Africa, where economic time series data often span only a few decades and are prone to structural breaks or measurement issues.

Despite its popularity and flexibility, the F-Bounds Test is not without limitations. Nkoro and Uko (2016) caution that while the procedure effectively handles the I(0) and I(1) series, it becomes invalid when any of the variables is integrated of order two I(2). Therefore, the F-Bounds Testing approach to cointegration presents a flexible and efficient method for exploring long-run economic relationships, especially in contexts where data constraints and mixed orders of integration prevail.

The study employed the ARDL F-Bounds Testing approach to investigate the existence of a long-run equilibrium relationship among the selected macroeconomic variables.

Table 4.7: F-Bounds Test

Critical Values (0.1-0.01), F-statistic, Case 3				F = 5.785, t = -2.527
	[I_0] [I_1] L_1 L_1	[I_0] [I_1] L_05 L_05	[I_0] [I_1] L_025 L_025	[I_0] [I_1] L_01 L_01
k_5	2.26 3.35	2.62 3.79	2.96 4.18	3.41 4.68

Table 4.7 presents the results of the F-Bounds test. The calculated F-statistic value was 5.785, the number of regressors in the long-run model was k = 5, and the model is estimated under Case 3 (unrestricted intercept and no trend), as specified in (Bertsatos *et al.*, 2022). Since the computed F-statistic of 5.785 exceeds the upper bound critical values at the 10%, 5%, 2.5%, and 1% levels, the study rejected the null hypothesis of no level relationship. This provided evidence of cointegration, meaning that a long-run relationship exists among the variables is included in the model.

4.7 Post Model Diagnostic Checks

Various post-estimation checks were carried out to ascertain the validity of the estimated Autoregressive Distributed Lag Model. For any econometric model to be considered valid and reliable for inference, it must satisfy a set of diagnostic criteria. Accordingly, the estimated Autoregressive Distributed Lag (ARDL) model was subjected to various post-estimation diagnostic checks to assess its robustness and the validity of the underlying assumptions. These tests help determine whether the model suffers from problems such as serial correlation, heteroskedasticity, non-normality of residuals or model misspecification, which could undermine the credibility of the results. The diagnostic checks conducted include the following;

4.7.1 Jacque Bera Test for Normality

The Lomnicki–Jacque Bera Test was conducted to assess whether the residuals of the estimated models are normally distributed to ensure the reliability of statistical inference.

Table 4.8 Results for the Lominick-Jacque Bera Test

Residuals	chi2	Prob > chi2
ENC	1.614	.669
GDP	1.971	.3815
RI	1.98	.4207
TOP	.1523	.9367
FDI	2.893	.2395
INF	2.686	.2845

Source: Research Data, 2025

4.7.2 Test for Multicollinearity

Multicollinearity refers to a situation where two or more explanatory variables in a regression model are highly linearly correlated, distorting the estimation of individual coefficients and reducing model interpretability. It inflates the standard errors, making statistical inference unreliable (Socrates, 2017). To detect multicollinearity, the study used the Variance Inflation Factor (VIF), which quantifies how much the variance of an estimated regression coefficient increases due to collinearity. As a rule of thumb, a VIF value exceeding 10 suggests serious multicollinearity (Qu, 2007).

Table 4.9: Results of Variance Inflation Factor

Variable	VIF	1/VIF
INF	1.66	0.600737
GDP	1.30	0.770650
TOP	1.24	0.804527
RI	3.24	0.3090
FDI	1.05	0.949783
Mean VIF	1.70	

Table 4.9 shows that all VIF values are below the critical threshold of 10, with a mean VIF of 1.70. This confirms that multicollinearity was not a concern in the model.

4.7.3 Test for Model Stability

The Cumulative Sum of Squares (CUSUMSQ) test, introduced by Brown, Durbin, and Evans (1975), was used to assess the stability of regression coefficients over time.

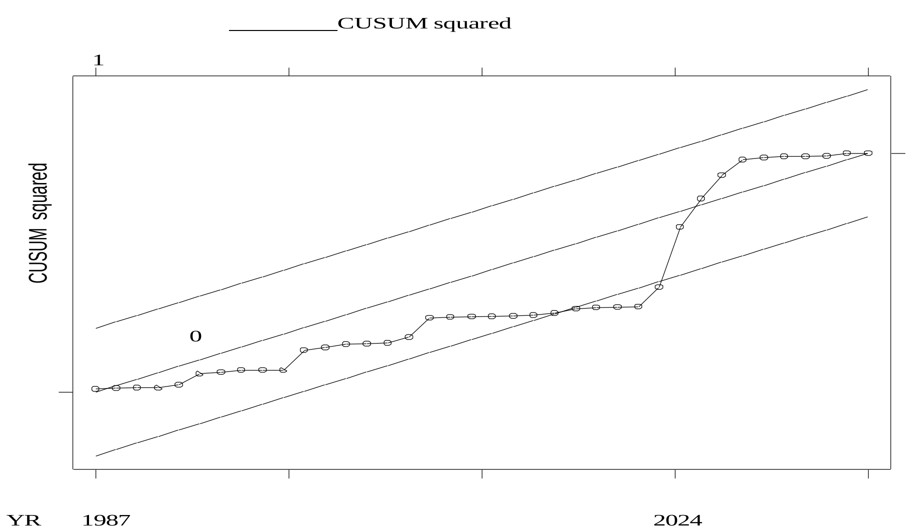

Figure 4.4: CUSUMSQ Test for Model Stability

Figure 4.4 shows CUSUMSQ plots, which largely remain within the 5% significance level of critical F-Bounds throughout the sample period. This shows the model has no structural instability. The conclusion was that estimated coefficients for both the long-run and short-run equations are consistent overtime. Therefore, the model was reliable for policy interpretation and forecasting purposes.

4.7.4 LM Test for Serial Autocorrelation

The Breusch–Godfrey Lagrange Multiplier (LM) test is used to detect serial correlation in the model's residuals when dealing with higher-order autocorrelation or lagged dependent variables. Unlike the Durbin-Watson statistic, the LM test is more flexible and valid under general conditions. According to Rodríguez-Veiga *et al*. (2020), the test involves regressing the residuals on the original regressors and their lagged values. A significant LM statistic indicates autocorrelation presence. Ensuring the absence of serial correlation is essential for maintaining unbiased standard errors, strengthening short-run and long-run coefficient interpretations. The test examined the null hypothesis of no serial autocorrelation (H_0) against the alternative of its presence.

Table 4.10: Serial Autocorrelation Table Breusch-Godfrey LM test for autocorrelation

Lags	$Chi2$	Df	Prob > Chi2
1	8.728	1	0.3100

As presented in Table 4.10, the p-value of 0.3100 exceeds the 5% significance level, indicating that the null hypothesis cannot be rejected. Consequently, it is concluded that the model does not suffer from serial autocorrelation and the residuals were independently distributed.

4.7.5 White's Test for Heteroscedasticity

Heteroscedasticity refers to the variance of the error term in a regression model. White's Test was used to detect whether the variance of the error terms in a regression model is constant. It is robust because it does not rely on the assumption of normally distributed errors and can detect various forms of heteroscedasticity, including non-linear patterns. The Test examines the null hypothesis of homoscedasticity (constant variance) against the alternative of heteroscedasticity (non-constant variance). A significant p-value ($p<0.05$) indicates the presence of heteroscedasticity, which invalidates standard errors and hypothesis tests. Confirming homoscedasticity is essential to ensure the reliability and efficiency of model estimates in time series modelling (Srivastava, 2020).

Table 4.11: White's Test for Heteroscedasticity

Source	Chi (2)	df	P
Heteroscedasticity	1.66	27	0.1972

Source: Compilation from STATA Output, 2025

As shown in Table 4.11, White's test yielded a p-value of 0.1972, which is greater than the 5% significance level. Therefore, the null hypothesis of homoscedasticity could not be rejected. It was concluded that the model does not suffer from heteroscedasticity, and the variance of the error terms is constant across observations.

4.8 Auto Regressive Distributed Lag Model (ARDL) Long Run and Short Run Estimates

The cointegration analysis confirmed the presence of a long-run relationship among the selected variables and hence, the use of the ARDLF-Bounds testing framework to estimate both short and long-run dynamics affecting energy consumption in Kenya over the period 1980–2024.

Table 4.12: Auto Regressive Distributed Lag Model (ARDL) with Error Correction Term

Sample 1980 – 2024 Log likelihood = 96.764689			R-squared=0.7632 Adj R-squared = 0.5821 Root MSE= 0.0144		
	D.ENC	Coef.	Std. Err	T	P > |t|
ADJ	**ENC**				
	L1	-.2948981	.1167094	-2.53	0.022
LR	**GDP**	.011343	.0078352	1.45	0.166
	FDI	.0557434	.023408	2.38	0.029
	INF	-.0342425	.0255154	-1.34	0.197
	RI	-.0710787	.0315517	-2.25	0.038
	TOP	-.0046639	.001473	-3.17	0.006
SR					
	ENC				
	LD	.5536584	.1869743	2.96	0.009
	FDI				
	D1	-.0100137	.0035481	-2.82	0.012
	LD	-.0040609	.0025676	-1.58	0.132
	RI				
	D1	-.01186	.0074928	-1.58	0.132
	LD	.02066	.0083716	2.47	0.025
	TOP				
	D1	.003316	.0010719	3.09	0.007
	LD	.001778	.0009276	1.92	0.072
	Cons	1.957008	.7661672	2.55	0.021

Notes: ADJ implies adjusted, LR-long run and SR is the short run, D1 Current change, LD Previous period's change

Table 4.12 reports the results of the Autoregressive Distributed Lag (ARDL) model incorporating the error correction term (ECT). The model demonstrates a good fit with an R-squared of 0.7632, suggesting that approximately 76.3% of the variation in energy consumption (ENC) is explained by the set of explanatory variables GDP, FDI, inflation (INF), interest rate (RI), and trade openness (TOP). The adjusted R-squared of 0.5821, while slightly lower, still indicates strong explanatory power, confirming that the selected variables collectively capture a significant proportion of the dynamics in energy consumption in Kenya. The remaining variation (around 23.7%) is attributable to other unobserved macroeconomic and structural factors, as well as random shocks. The coefficient of the lagged error correction term (L1.ENC) is –0.2949, indicating that approximately 29.5% of the disequilibrium from the previous period is corrected within the current period.

4.8.1 Error Correction Term (ECT) and Speed of Adjustment

The coefficient of the lagged energy consumption variable ($ENC_{(-1)}$), which represents the Error Correction Term (ECT), is negative and statistically significant (–0.2949, p = 0.022). This satisfies the theoretical expectation for a valid long-run relationship. The scale of ECT means that (on average) about 29.5 percent of an imbalance of short-run energy consumption is eliminated within one year suggesting that the process of approaching the LR equilibrium is rather fast.

From the economic point of view, this means that any energy consumption shocks (for example, due to macroeconomic fluctuations like inflationary pressure, interest rate fluctuations or external trade shocks) are gradually corrected over time. This comparably low adjustment rate however, shows that there are rigidities in the energy sector of Kenya which includes infrastructure constraints, regulatory delays and use of traditional sources of energy.

4.8.2 Run Effects of Macroeconomic Variables on Energy Consumption

The short-run dynamics of the ARDL model capture the immediate impact of changes in macroeconomic variables on energy consumption (D.ENC). These effects reflect temporary adjustments before convergence to the long-run equilibrium.

4.8.2.1 Interest Rate (RI)

The contemporaneous change in interest rate (D1. RI) is negative but statistically insignificant (–0.0119, p = 0.132), suggesting that immediate interest rate fluctuations do not significantly affect energy consumption in the same period. However, the lagged change in interest rate (LD. RI) is positive and statistically significant (0.0207, p = 0.025).

4.8.2.2 Diagnostic and Model Validity Considerations

The statistical significance of the ECT, combined with satisfactory goodness-of-fit measures, confirms the robustness of the ARDL specification. The model satisfies stability and convergence conditions, supporting its suitability for policy analysis. Nevertheless, diagnostic tests such as heteroscedasticity, serial correlation, and multicollinearity (reported elsewhere in the chapter) further reinforce confidence in the reliability of the estimated coefficients.

Table 4.13 presents a summary of the hypotheses tested using the ARDL long run model, along with the corresponding conclusions drawn from the analysis as indicated at 5% level of significance.

Table 4.13: Summary of the Hypothesis Tested using the ARDL Long Run Model

Hypothesis	**β-Value**	**P-Value**	**Decision**
HO1: GDP has no significant effect on Energy Consumption	0.011343	0.166	Failed to Reject
HO2: FDI has no significant effect on Energy Consumption	0.0557434	0.029	Rejected
HO3: Inflation (INF) has no significant effect on Energy Consumption	-.0342425	0.197	Failed to Reject
HO4: Interest Rate (RI) has no significant effect on Energy Consumption	–0.0710787	0.038	Rejected
HO5: Trade Openness (TOP) has no significant effect on Energy Consumption	–0.0046639	0.006	Rejected

Table 4.14 presents a summary of the hypotheses tested using the ARDL short run model, along with the corresponding conclusions drawn from the analysis as indicated at 5% level of significance.

Table 4.14: Summary of the Hypothesis Tested using the ARDL Short Run Model

Hypothesis	**β-Value**	**P-Value**	**Decision**
HO2: FDI has no significant effect on Energy Consumption			
D1	-.0100137	0.012	Rejected
LD	.02066	0.132	Failed to Reject
HO4: Interest Rate (RI) has no significant effect on Energy Consumption			
D1	-.01186	0.132	Failed to Reject
LD	.02066	0.025	Rejected
HO5: Trade Openness (TOP) has no significant effect on Energy Consumption			Rejected
D1	.003316	0.007	Rejected
LD	.001778	0.072	Failed to Reject

CHAPTER FIVE

DISCUSSION

5.1 Overview

This chapter presents a coherent synthesis and logical interpretation of the study's results.

5.2 Descriptive Statistics

From the results in Table 4.1, the descriptive statistics reveal that Kenya's energy consumption averaged 477.56 kWh over the study period, with a moderate variability of 34.53 kWh. Foreign Direct Investment (FDI) inflows, expressed as a percentage of GDP, averaged 0.69% with a standard deviation of 0.72%. The minimum value of –0.005% indicates years of net outflows, while the maximum of 3.09% of GDP represents peak inflow years. These findings correspond with Wanja (2017), who noted that Kenya's FDI climate during the early 1980s was marked by policy reversals and governance concerns that deterred investors, despite initial liberalization efforts in the late 1970s. By comparison, UNCTAD (2010) reported that the average FDI inflows for Sub-Saharan Africa during the 1980–2000 period was about 1.2% of GDP, slightly higher than Kenya's 0.69%.

This suggests that Kenya lagged behind regional averages, reflecting a comparatively less attractive investment environment, though peak years demonstrate that policy reforms had potential to temporarily boost foreign investor confidence. The interest rate averaged 7.16%, with a relatively high standard deviation of 6.49%. Values ranged from –10.1% to 21.1%, reflecting extreme fluctuations linked to monetary policy reforms and liberalization under IMF structural programs in the 1980s. This mirrors findings by Were and Wambua

(2013), who highlighted that interest rate volatility in Kenya constrained private sector credit access and investment. Compared to Uganda, where Kasekende and Atingi-Ego (2003) documented average interest rates of 13% post-liberalization, Kenya's mean of 7.16% was lower but considerably more volatile. The negative rates during certain years' highlight distortions in financial markets, which are rarely observed in regional economies, indicating unique monetary challenges in Kenya.

Trade openness averaged 50.96% of GDP, with values ranging between 27.24% and 72.86%. This indicates a moderately open economy, with noticeable fluctuations due to shifting trade policies and external shocks. Githanga (2015) noted that Kenya's trade patterns during this period were shaped by efforts to diversify exports and adjust tariffs under regional frameworks such as the East African Community (EAC). Compared to Ghana, where Aryeetey, Harrigan, and Nissanke (2000) reported trade openness averaging 64% during the same era, Kenya's lower mean indicates a relatively slower pace of global integration. However, the upper bound of 72.86% suggests that in some years, Kenya achieved openness levels comparable to other liberalizing African economies, though these gains were not sustained.

5.3 ARDL Long-Run Estimates and Discussion

5.3.1 The Effect of Foreign Direct Investment (FDI) on Energy Consumption in Kenya

In the long-run estimates, Foreign Direct Investment (FDI) recorded a positive and significant coefficient of 0.0557 ($p = 0.029$), suggesting that increased FDI inflows stimulate energy demand in Kenya. This result implies that a 1% increase in net FDI inflows, expressed as a share of GDP, leads to a 5.57% rise in energy consumption, holding all other factors constant. This relationship can be explained by the role of FDI in expanding industrial activity, infrastructure development, and modernization of energy-intensive sectors. Capital inflows from foreign investors boost production capacity, facilitate technology transfers, and enhance demand for energy in manufacturing, transport, and services. Consequently, FDI acts as both a direct and indirect driver of energy consumption as economic activity intensifies.

These findings align with Kahouli and Omri (2017), who found that in MENA and BRICS countries, FDI increased energy consumption by between 3% and 7%, depending on the sectoral distribution of investments. Similarly, Shahbaz (2024) observed a statistically significant long-run elasticity of 0.061 for FDI with respect to energy consumption in developing economies, reinforcing the argument that FDI stimulates energy-intensive growth. Warsame *et al*. (2023) also emphasized that capital inflows accelerate infrastructural development and industrialization, thereby expanding electricity and fuel demand. In the Kenyan context, this relationship is plausible given that FDI during the 1980s and 1990s often targeted infrastructure, telecommunications, and extractive industries all of which are energy-intensive (UNCTAD, 2010).

However, the results contrast with a study by Ullah *et al*. (2022), which, using dynamic panel estimations across developed and developing countries, found that in some developing economies, FDI reduced energy consumption in the long run.

5.3.2 The Effect of Interest Rate (RI) on Energy Consumption

The long-run analysis reveals that interest rate (RI) had a negative and statistically significant coefficient of –0.0711 ($p = 0.038$), implying that rising interest rates are associated with reduced energy consumption in Kenya. This suggests that a 1% increase in the real interest rate leads to a 7.11% decline in energy consumption, holding other factors constant. The relationship can be explained by the fact that higher interest rates raise borrowing costs, discouraging both households and firms from taking credit for energy-intensive investments in sectors such as manufacturing, transport, and real estate. As businesses scale down expansion and production plans due to tighter credit conditions, the associated demand for electricity and fuel contracts. Similarly, elevated interest rates reduce household purchasing power and disposable income, thereby lowering household energy consumption.

This result is consistent with research by Wu *et al*. (2023), which studied dynamic energy efficiency in OECD countries and found that a 1% increase in interest rates reduced industrial energy consumption by approximately 5–6% during the COVID-19 pandemic. The contractionary effect was most pronounced in capital-intensive industries, where financing costs directly influence investment and energy use. Similarly, a study by Rahman *et al.* (2019), on South Asia, confirmed that higher interest rates dampen investment activity, resulting in a decline in energy demand. Their system-GMM estimates indicated that a 1% rise in interest rates reduced energy use by 4.8% across the region, corroborating the findings in Kenya that tighter credit markets suppress energy demand.

Conversely, some studies report differing results. Chen *et al*. (2021), analyzing a panel of emerging economies between 1995 and 2018, found a positive elasticity of 0.03 between interest rates and energy consumption. The study argued that in financially open economies, higher interest rates attract foreign capital inflows, which stimulate investment activity and ultimately raise energy demand. This “capital inflow effect” differs from Kenya’s context, where underdeveloped credit markets and high borrowing costs restrict access to financing, leading to contraction rather than expansion in energy consumption.

Additionally, Lin and Moubarak (2014) investigated China's industrial sector and reported that a 1% rise in interest rates reduced energy consumption by 6.4%, closely mirroring Kenya's elasticity (–0.0711). In Sub-Saharan Africa, Ouedraogo (2013) found that restrictive monetary policy indirectly reduced energy use by slowing economic activity, particularly in energy-intensive industries. These studies reinforce the view that, in economies where energy demand is highly sensitive to credit availability, interest rate hikes significantly reduce energy consumption.

Therefore, the findings for Kenya indicate that monetary policy plays a critical indirect role in shaping energy demand. Unlike emerging economies with strong capital inflow channels, Kenya's domestic credit market constraints mean that higher interest rates primarily restrict access to financing, reducing both industrial activity and household energy demand. Policymakers should therefore recognize the dual role of interest rates: while effective in managing inflationary pressures, excessively high rates may inadvertently depress energy demand and economic growth by constraining investment. Coordinated energy and monetary policies are therefore essential to balance macroeconomic stability with sustainable energy use.

5.3.3 The Effect of Trade Openness (TOP) on Energy Consumption

The ARDL long-run results indicate that trade openness (TOP) has a negative, statistically significant effect on energy consumption (–0.0047, $p = 0.006$). Their panel estimates showed that a 1% rise in trade openness reduced energy consumption by approximately 0.32%, primarily through the adoption of modern technologies and restructuring toward less energy-intensive sectors. Similarly, Saidi and Hammami (2015), using data from 58 countries, found that trade openness reduced energy demand in the long run, with elasticities ranging between –0.25 and –0.40, depending on the level of development. These results are consistent with the Kenyan case, where technology adoption and efficiency gains appear to outweigh the expansionary effects of trade on energy demand.

However, not all studies support this negative relationship. Rafindadi and Usman (2019), using the Maki cointegration test for South Africa, found a positive and significant relationship between trade openness and energy consumption, suggesting that trade expansion can intensify energy use, particularly when exports are concentrated in energy-intensive sectors such as mining and heavy manufacturing. Their results indicated that a 1% rise in trade openness increased energy consumption by 0.21% in South Africa. Similarly, Shahbaz *et al.* (2013), in a study on China, revealed that trade openness was positively associated with energy use, particularly during the rapid industrialization period, where increased exports were heavily dependent on coal and electricity. These findings contrast with Kenya's context, where the export base is relatively less energy-intensive (dominated by tea, coffee, and horticulture) and trade openness has encouraged the adoption of imported energy-efficient technologies rather than intensifying domestic energy use.

The evidence therefore suggests that the effect of trade openness on energy consumption is highly context-dependent. In resource and energy intensive economies, greater openness increases energy demand, while in economies like Kenya, openness facilitates technology transfer and efficiency improvements that reduce energy use. This highlights the importance of policy design: while trade liberalization offers opportunities for technological upgrading, complementary policies such as targeted incentives for renewable energy adoption, efficient industrial practices, and environmental standards are essential to ensure that openness continues to reduce energy demand and promote sustainable growth.

5.3.4 The Effect of Economic Growth (GDP) on Energy Consumption

The ARDL long-run estimates revealed that GDP had no statistically significant impact on energy consumption in Kenya, with a coefficient of $\beta = 0.011343$ ($p = 0.166$). But GDP in energy intensive economies is a significant force behind energy demand. For example, Ang (2007) in Malaysia found a long-run elasticity of $\beta = 0.62$ ($p < 0.01$), confirming a strong growth–energy nexus. In South Asia, Shahbaz *et al*. (2016) reported that GDP significantly influenced energy use, with elasticities ranging between $\beta = 0.61$–0.85 ($p < 0.05$) across developing economies, emphasizing that economic expansion in industrializing countries often necessitates higher energy inputs. Similarly, Akinlo (2008) in Nigeria found a significant positive coefficient ($\beta = 0.47$; $p < 0.05$) linking growth directly to fossil-fuel consumption.

Thus, the insignificance of GDP in Kenya's case contrasts sharply with the experiences of more industrialized developing economies. It reflects Kenya's unique economic structure, where expansion occurs largely in service-oriented and renewable-driven sectors, thereby weakening the traditional growth–energy consumption relationship.

5.3.5 The Effect of Inflation (INF) on Energy Consumption

The ARDL long-run estimates showed that inflation had no statistically significant effect on energy consumption in Kenya, with a coefficient of $\beta = -0.0342425$ ($p = 0.197$). This means that although inflationary shocks can influence energy affordability and production costs in the short run, they do not permanently shape long-run consumption patterns.

Kenya's resilience may be explained by its structural composition and rapid adoption of renewable energy, which reduces exposure to price fluctuations.

Similarly, Hossain (2015), in a panel study on South Asian economies, found that the coefficient of inflation on energy consumption was statistically insignificant ($\beta = -0.021$, $p > 0.10$), suggesting that inflationary changes did not meaningfully affect long-run demand. Ozturk and Acaravci (2010), analyzing Turkey, also reported an insignificant coefficient ($\beta = -0.009$, $p = 0.23$) for inflation in their ARDL model, confirming that price-level volatility did not structurally influence energy demand. Belloumi (2009) also found that in Tunisia, the long-run inflation coefficient was not significant ($\beta = -0.015$, $p = 0.31$), further supporting the argument that energy consumption is shaped more by industrial activity and policy than by inflationary shocks.

By contrast Soytas and Sari (2003), using a VAR model for Turkey, found that inflation had an indirect but significant effect on energy consumption through its impact on industrial output, with the coefficient for inflation on energy demand estimated at $\beta = -0.043$ ($p < 0.05$). Similarly, a study of China by Zhang and Cheng (2009) reported that inflation significantly influenced energy consumption, with a coefficient of $\beta = -0.056$ ($p < 0.01$), reflecting the high sensitivity of China's industrial sector to macroeconomic volatility. In Nigeria, Akinlo (2008) found a long-run inflation coefficient of $\beta = -0.071$ ($p < 0.05$), indicating that persistent inflation substantially reduced energy consumption, largely due to decreased affordability of petroleum-based products.

These findings show that while inflation significantly influences energy demand in highly industrialized or fossil-fuel-dependent economies, in countries such as Kenya, Tunisia, and Turkey, its long-run effect is statistically insignificant. This reinforces the interpretation that Kenya's long-term energy demand is primarily driven by structural and policy factors rather than by macroeconomic price fluctuations.

5.4 ARDL Short Run Estimates and Discussions

In the short run, the lagged difference of energy consumption (LD.ENC) was positive and statistically significant (0.5537, p = 0.009), indicating strong inertia or persistence in energy use patterns. This suggests that past energy consumption levels continue to influence current consumption behavior, due to fixed infrastructure or habits that do not adjust immediately to economic shocks. This finding is consistent with Zhang and Cheng (2009), a study on energy consumption, carbon emissions, and economic growth in China that reported similar short-run dynamics in China, attributing it to the slow adjustment of energy systems and consumer behavior.

5.4.1 The Impact of Foreign Direct Investment (FDI) on Energy Consumption in Kenya

The short-run results reveal that the first difference of Foreign Direct Investment (D1.FDI) negatively and significantly affects energy consumption (–0.0100, p = 0.012). This implies that when there is an increase in FDI inflows in the short-run, domestic energy consumption will reduce immediately. This could be due to the time delay between foreign capital inflow and operationalization of the investment projects. FDI in the initial years could be directed towards financial services, consultancy, or technology-oriented industries which are relatively less energy-intensive. On its part, the early phases in investing may involve administrative and planning costs and that the impacts on energy demand may take a long time to be experienced.

This finding is comparable to that of Tang and Tan (2013) which showed that the effect of

FDI negatively and significantly affected the short-run energy consumption in Malaysia. This was due to sluggish effects on productivity and orientation of FDI to sectors with lesser energy demands during the initial stage of investment. Similarly, a study of MENA countries by Omri and Kahouli (2014) using dynamic simultaneous-equations models, established that there was an initially energy-saving effect of FDI inflows associated with energy efficiency which reduced short-term energy consumption, and the long-run impact of industrial expansion on energy consumption was high.

5.4.2 The Impact of Interest Rate (RI) on Energy Consumption

The short-run estimates show that the lagged difference of interest rate (LD. RI) had a positive and statistically significant effect on energy consumption (0.0207, $p = 0.025$). For instance, Sadorsky (2010), in a study on emerging economies, observed that a 1% increase in interest rates was associated with a short-run rise of 0.18% in industrial energy consumption, arguing that firms tend to complete ongoing projects despite rising financing costs. Similarly, Chen *et al*. (2021), examining interest rate policies and energy consumption in 20 emerging economies (1995–2018), reported that a 1% increase in interest rates initially raised energy demand by 0.12% due to capital inflows and heightened short-run production activity, particularly in construction and infrastructure. However, the effect reversed in the long run as financing costs began to restrain new projects.

On the contrary, studies from more developed contexts have found the opposite effect. For example, Wu *et al.* (2023), analyzing OECD economies during the COVID-19 monetary tightening cycle, documented that higher interest rates immediately curtailed industrial energy consumption, particularly in energy-intensive capital goods sectors. The study's results suggested that in highly financialized and credit-sensitive economies, interest rate changes are transmitted more quickly, leaving little room for short-run surges in energy use.

In the Kenyan context, the positive short-run relationship likely reflects the time lag in monetary policy transmission and the structure of the economy. Much of Kenya's industrial and infrastructural investment is externally financed through loans and foreign inflows, meaning projects are often locked in well before monetary tightening takes effect. Moreover, sectors such as real estate, manufacturing, and transport may maintain momentum in the short term even under rising interest rate conditions, contributing to continued energy demand. Over time, however, the tightening of credit conditions is expected to moderate energy use as new investments are postponed or scaled down.

5.4.3 The Impact of Trade Openness (TOP) on Energy Consumption

In the short run, trade openness (D1.TOP) had a positive, statistically significant effect on energy consumption (0.0033, $p = 0.007$). Similarly, Hossain (2011) studied South Asian economies and documented that trade openness initially intensified energy use by 0.12%, reflecting increased industrial production and transport demand.

However, contrasting evidence has also been reported. For instance, Rafindadi and Usman (2019), focusing on South Africa, found that trade openness in the short run raised energy consumption by 0.19%, but in the long run contributed to higher environmental degradation due to heavy reliance on coal-intensive industries. Conversely, Akbar *et al*. (2020), analyzing Southeast Asian countries, found that while trade openness initially increased energy demand, the effect was smaller (0.09%) and tapered off faster as countries integrated cleaner technologies and benefited from global competition.

In the Kenyan context, the short-run positive effect reflects the energy-intensive nature of its trade-related activities, such as horticultural exports (cold storage, air transport), textile manufacturing, and transport logistics. These sectors demand substantial electricity, petroleum, and other energy inputs to meet international market standards and maintain competitiveness. However, over time, integration into global markets may promote technological upgrading, efficiency improvements, and renewable energy adoption, leading to a more sustainable energy trajectory.

5.4.4 The Impact of Economic Growth (GDP) on Energy Consumption

In the short run, GDP was found to be statistically insignificant with a coefficient of 0.011343, a t-value of 1.45, and a p-value of 0.166, which is above the 5% significance leve. Similarly, Apergis and Payne (2012) analyzed 88 countries using panel error correction models and found long-run bidirectional causality between GDP and energy consumption, with elasticity values ranging between 0.50 and 0.70, but short-run results were mixed and statistically insignificant in low-income economies. This contrasts with high-income countries, where short-run GDP shocks were significant drivers of energy demand. The Kenyan findings resonate more with the low-income country group, reflecting weaker industrial dependence on energy in the short run.

5.4.5 The Impact of inflation (INF) on Energy Consumption

In the short run, inflation was also statistically insignificant, with a coefficient of –0.0342425, a t-value of –1.34, and a p-value of 0.197, again exceeding the 5% threshold. However, in the short run, inflation's effect was insignificant, similar to the Kenyan results (Coef. = –0.0342425, p = 0.197).

The contrast is important for Kenya, where, similar to South America, subsidies and electricity price regulations cushion households and firms from immediate price shocks, leading to the short-run insignificance of inflation on energy demand (Coef. = –0.0342425, p = 0.197). However, the long-run consequences may still emerge if inflation erodes fiscal capacity and undermines investment in energy infrastructure.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This chapter provides a summary of the key findings, draws conclusions based on the results, offers policy and practical recommendations, highlights the study's limitations, and outlines areas for future research.

6.2 Summary of the Findings

This study examined the effects of selected macroeconomic variables on energy consumption in Kenya by estimating short- and long-run relationships using the ARDL framework.

6.3 Conclusion of the Study

This study examined the relationship between selected macroeconomic variables and energy consumption in Kenya using time-series data and an ARDL modelling framework. The analysis focused on identifying both short-run dynamics and long-run associations among energy consumption, economic growth, inflation, interest rates, trade openness, and foreign direct investment.

The empirical results show that there is long-run link between energy consumption and the selected macroeconomic variables using the ARDL bounds testing procedure.

6.4 Recommendations of the study

Given that inflation and interest rates significantly influence energy consumption, maintaining macroeconomic stability should be treated as an immediate policy priority. The Central Bank of Kenya, in conjunction with the National Treasury, should do monetary and fiscal policy to manage the inflationary pressures and prevent very fluctuating interest rates in the short to medium term. Stable macro-economic conditions lower uncertainty for households and firms and help to facilitate more predictable energy use and investment in energy-using capital and infrastructure.

The study results with respect to the trade openness reveal that higher level of openness can be helpful in reducing the energy consumption by efficiency and technology transfers. Medium to long-term, the ministry of trade (in consultation with the ministry of energy and EPRA) should encourage policies to enable importing of energy-efficient machines and clean technologies. Structural changes towards less energy-intensive production, while remaining competitive in international markets, can be facilitated by strategic trade partnerships and targeted incentives.

Lastly, high losses and inefficiency in the electricity sector in the short to medium term are in need of better regulation. EPRC should ramp up work to cut down on technical and commercial losses by further monitoring of performance, introducing efficiency standards, and facilitating infrastructure upgrades. Better efficiency of the system will make it possible to increase the generation capacity, which will lead to efficient and reliable energy use, hence increasing the productivity of industries and welfare of households.

6.5 Suggestions for Future Study

Future research on energy consumption in Kenya can build on the study findings by extending both the methodological approaches and thematic scope of analysis.

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APPENDICES

Appendix A: Data Collection Schedule

General Information about the Institution

1. Institution Name …………… ………………...………………...…..
2. Name of officer in-charge……………………………………………
3. Location…………………………………………………………...
4. Economic function of the Institution…………………………..... ….

Please provide the following information

VARIABLE	SPECIFICS	1980-1990	1991-2001	2002 2012	2013 2023	2024
Economic Growth Measures	GPD per capita growth (annual %)					
Inflation Rate (KES)	Consumer Price Index (annual %)					
Trade Openness	Trade (% of GDP)					
Foreign Direct Investment	Net Inflows (% of GDP)					
Interest Rate	Real Interest Rate (Percentage)					
Energy Consumption (KW)	Total Energy Consumption (kWh)					

(*Where absolute values are not available, indicate the estimated per cent increase or decrease)*

Thank you for your co-operation. God Bless you

Appendix B: Authorization Letter

University of Eldoret
Fame of knowledge and innovation

P. O. Box 1125 - 30100, Eldoret, Kenya
Tel: +254 53 2063257 /2033712/13 Ext. 2358
Mob: 0774249552;; Fax: +254 53 206 3257
E-mail: bpgs@uoeld.ac.ke
Website: www.uoeld.ac.ke

OFFICE OF THE DEPUTY VICE-CHANCELLOR (ASA)
(Directorate of Board of Postgraduate Studies)

Our Ref: UoE/B/BPGS/NACO/060 **Date:** 19th July, 2025

The Chief Executive Officer
National Commission for Science, Technology & Innovations
(NACOST)
P.O. Box 30623 - 00100
NAIROBI.

Dear Sir/Madam

SUBJECT: REQUEST FOR RESEARCH PERMIT - SHARLEEN ABURUKI (REG.NO.SECO/AEC/M/002/23)

The above subject matter refers.

The above named is a bonafide Masters student in the Department of Economics, School of Business, Economic and Management Sciences. The applicant has completed her coursework and successfully defended her proposal in readiness for commencement of research. Her research is entitled "*Effects of Macroeconomics Variables on Energy Consumption in Kenyan*".

By this letter, I request you to issue Ms. Sharleen Aburuki with a research permit to enable her proceed with her survey for her to write thesis.

Your support will be highly appreciated.

Yours faithfully

DIRECTOR
Board of Postgraduate Studies
University of Eldoret.

PROF. SAMUEL LUTTA
DIRECTOR, BOARD OF POSTGRADUATE STUDIES

Appendix C: NACOSTI License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **425908**

Date of Issue: **09/July/2025**

RESEARCH LICENSE

This is to Certify that Ms.. Aburuki Sharleen of University of Eldoret, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nairobi, Nakuru, Uasin-Gishu on the topic: Effect of Macroeconomic Variables on Energy Consumption in Kenya for the period ending : 09/July/2026.

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Appendix D: Similarity Report

DrillBit

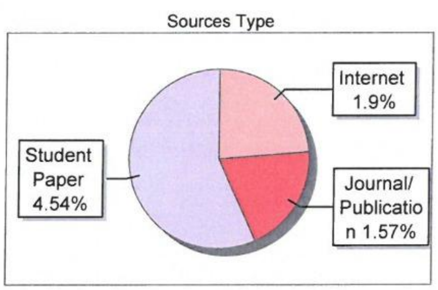
The Report is Generated by DrillBit Plagiarism Detection Software

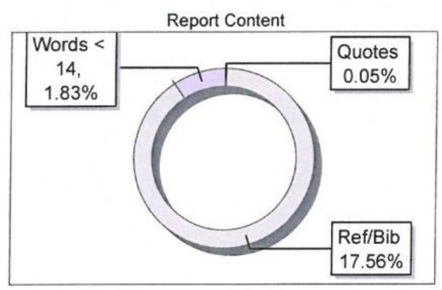
Submission Information

Author Name	SHARLEEN ABURUKI
Title	EFFECT OF SELECTED MACROECONOMIC VARIABLES ON ENERGY CONSUMPTION IN KENYA
Paper/Submission ID	5961054
Submitted by	petronilla.omete@uoeld.ac.ke
Submission Date	2026-06-08 13:02:38
Total Pages, Total Words	122, 27392
Document type	Thesis

Result Information

Similarity **8 %**





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Quotes	Not Excluded
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Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

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