MAKERERE UNIVERSITY

MAKERERE UNIVERSITY BUSINESS SCHOOL

ECONOMIC GROWTH, URBANIZATION, ELECTRICITY PRICES AND ELECTRICITY CONSUMPTION IN UGANDA

BY

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PLAN A

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DECLARATION

I, **Mwesigwa Noa** declare that this dissertation is my original work and has never been published and or submitted to any University or Institution of learning for any award; where authored work has been referred to, citation was made in recognition of their work.

Signed..... Date..30/10/2023.....

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APPROVAL

This dissertation has been under our supervision and it is ready for submission to Makerere University Business School with our approval.

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Signed……. Date……30/10/2023

MS. VINCENT KATUTSI PATSY

DEDICATION

The dissertation is dedicated to all my family members especially my parents for their continuous guidance and support in my academic and professional career

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LIST OF ABREVIATIONS AND ACRONYMS

AC	Absence of Causality
BD	Bi- directional Causality
C	Consumption
EC	Electricity Consumption
EP	Electricity retail Price
ERA	Electricity Regulatory Authority
G	Government Expenditure
GDP	Gross Domestic Product
I	Investments (Savings)
IEA	International Energy Agency
IRENA	Iternational Renewable Energy Agency
kWh	Kilo watts
MEMD	Ministry of Energy and Mineral Development
MENA	Middle East and North Africa
MW	Mega Watts
NDP	National Development Plant
NX	Net of Exports and Imports
P	Population growth
PERD	Public Enterprise Reform and Divestiture Programme
PPA	Power Purchase Agreement
PSA	Power Sales Agreement
REA	Rural Electrification Agency
REB	Rural Electrification Board
REF	Rural Electrification Fund
SDG	Sustainable Development Goals
UB	Urban Population
UBOS	Uganda Bureau of Statistics
UEB	Uganda Electricity Board

UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
US$ / US¢	American Dollars / cents
USh	Ugandan Shilling
VAR	Vector Auto Regression
VECM	Vector Error Correction Model
WB	World Bank
WDI	World Development Indicators
Y	Economic growth

ABSTRACT

The Study examines the long-run relationship between economic growth, urbanization and electricity consumption in Uganda while controlling for electricity tariffs. The Study used quarterly time series data from the Electricity Regulatory Authority of Uganda and the World Bank. The Study tests for the unit root and cointegration using Augmented Dickey-Fuller and Johansen cointegration respectively. The existence of a long-run relationship allowed the Study to examine the existence of the series under investigation using vector error correction causality/block exogeneity Wald tests. The Study results show population, urbanization and economic growth have a positive and significant long-run effect on electricity consumption while electricity tariff has a negative and significant effect on electricity consumption. The Study, therefore, recommends that the government through Electricity Regulatory Authority should strive to make electricity affordable by lowing tariffs and allowing the provision for load shifting at peak to off-peak hours by domestic consumers, manufacturers and local small businesses. The Study further recommends that government should boost the purchasing power for both rural and urban people through creating self-help projects and cheap financial credits for capital development.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter covers the background of the Study, problem statement, purpose of the Study, Objectives of the Study, research hypothesis, scope of the Study, significance of the Study and the conceptual model.

1.1 Background of the Study

Energy consumption plays an important role in the growth and development processes as it facilitates production and improves household welfare (Mawejje & Mawejje, 2016). In this bifurcated world of agrarian and industrial economies, electricity is important for both. Developed countries need electricity to run their industrial sector while developing countries need it to be able to make progress in economic development (Burke et al., 2018). Globally, electricity consumption has been gaining greater attention in recent years (Ansu-Mensah & Kwakwa, 2022). This growing global concern is embodied in Sustainable Development Goal (SDG) 7 (United Nations, 2018). Specifically, this goal seeks to ensure access to affordable, reliable, sustainable modern energy for all. As of 2020 however, 789 million people live without electricity and hundreds of millions more live with insufficient or unreliable access to it. Nearly 3 billion people cook with polluting fuels like wood or other biomass, resulting in indoor and outdoor air pollution that causes widespread health impacts. In addition, only 48.1% of the SSA population relied on electricity, falling short of the 95% target (International Energy Agency IEA, 2020). In Uganda, electricity consumption stands at 22% against the target of 60% (UBOS, 2020). This electricity consumption discrepancy necessitates a better understanding of the key factors that explain it.

Consequently, the rapid decline in renewable energy costs, improving energy efficiency, widespread electrification, increasingly "smart" technologies, continual technological breakthroughs and well-informed policy-making all drive increasing electricity consumption (International Renewable Energy Agency [IRENA], 2020). In Uganda, electricity consumption remains a key priority for the government and other stakeholders through different ambitious programs geared towards increasing economic growth to increase consumption of the electricity that is generated for instance through electricity connection policy, NDP 111, Vision 2040, yet Uganda currently has one of the lowest rates of electricity consumptions per capita (100 kWh per capita) in the world. Despite the recent developments and renewed Government commitment to increase electricity consumption through economic growth, there is limited empirical work on the relationship between economic growth, population and electricity consumption in Uganda.

Debates regarding the relationship between economic growth, population, urbanization and electricity consumption have attracted a vast amount of attention from practical, theoretical and empirical perspectives in recent years (Tiwari, Eapen & Nair, 2021; Wang, Fu, & Wang, 2021). The determinants of electricity consumption in Uganda are not well known and their effects are still debatable (Mawejje & Mawejje, 2016). Although in other jurisdictions these factors have been found to significantly influence electricity consumption. As a redult electricity consumption remains low even in the face of these factors, there are few also studies on the subject (Mutumba *et al*., 2022; Alinaitwe,2023). Furthermore, Mawejje & Mawejje (2016) also established a long-run causality running from electricity consumption to industry; a unidirectional short-run causality running from the services sector to electricity consumption; and neutrality in the agricultural sector. Liu *et al*. (2020) found a positive impact of urbanization on electricity

consumption with significant spatial-temporal heterogeneity. Bucci (2008) revealed that population growth may either positively or negatively affect economic growth because of dilution effects. The causal link between urbanization, economic growth, electricity consumption and electricity consumption has been a contentious issue in the developmental economics literature (Khan et al., 2021); the association continues to be a recurring economic issue. The extant literature above indicates five causal relationships between economic growth, electricity prices, urbanization and electricity consumption; (1) the neutrality hypothesis; (2) the conservation hypothesis; (3) the growth hypothesis; (4) the feedback hypothesis and the dilution effects, thus the current literature on the nature of the causal relationship between economic growth, urbanization, electricity prices and electricity consumption is not conclusive.

The Government of Uganda has undertaken different interventions to increase electricity consumption. For instance, the government has initiated the Energy for Rural Transformation Program (ERT) which is funded by the World Bank cross-cutting programme aimed at improving rural household energy access. These programs aim to provide electricity access to off-grid communities, thus increasing electricity consumption in rural regions. The government also offers incentives for renewable energy projects. This includes tax breaks and regulatory support for solar, wind, and hydropower initiatives, which can contribute to increased electricity consumption. The government has introduced reduced electricity tariffs for industrial consumers. This encourages existing industries to expand their operations and new industries to establish themselves in Uganda. However, fifty-one per cent of households in Uganda had access to at least one source of electricity in 2019, including the national grid, solar lighting systems/lanterns, solar home systems, mini-grids and generators. The country's electricity connectivity rate of

24% is still one of the lowest in Africa compared with the Sub-Saharan average of 43% (2019). Additionally, there is insufficient access to modern energy sources and services such as Liquefied Petroleum Gas (LPG), biogas and improved cookstoves for clean cooking, mainly due to higher upfront costs than traditional sources.

1.2 Problem Statement

Electricity consumption plays a pivotal role in driving economic growth, improving living standards, and fostering industrial development. However, in Uganda, despite extensive efforts to improve the situation, the country's electricity consumption remains alarmingly low. With a per capita electricity consumption of only 215 kWh, Uganda falls significantly short of the sustainable development goal target of 3,668 kWh. Additionally, the electricity connectivity rate in the country stands at a mere 28%, which is one of the lowest rates in Africa, notably lower than the Sub-Saharan average of 43% (MEMD, 2022; Energy Policy, 2023). Reports emphasize the significant income disparities in Uganda, with a large portion of the population falling below the poverty line, the slow pace of urbanization in Uganda has resulted in a substantial rural population with limited access to electricity, impacting overall consumption, the cost of electricity in the country is often cited as one of the highest in the region, making it unaffordable for many individuals and businesses (World bank, 2020). High prices discourage investment in energy-intensive industries and limit the willingness of consumers to increase their electricity usage. It can be noted that significant income disparities, slow pace of urbanization and high electricity prices could explain low electricity consumption in Uganda. While there is a substantial body of research on factors influencing electricity consumption, particularly economic growth, urbanization, and electricity prices, there remains a noticeable gap in studies that specifically investigate their combined effect in the context of Uganda (Abbasi, Abbas &

Tufail, 2021; Khan *et al*., 2021). Most of the existing studies concentrated on Asian and American economies, giving little attention to the African continent and more specifically Sub-Saharan Africa (Mutumba *et al*., 2022). Therefore, inadequate attention to all the factors potentially denies us a clear understanding of their effect on electricity consumption, especially in Uganda. Uganda presents a unique socioeconomic and demographic environment characterized by a predominantly rural population, income disparities, and varying levels of urbanization. Existing studies from developed countries may not adequately capture the nuances of the Ugandan context. Besides, economic growth, urbanization, and electricity prices are closely interrelated and influence each other. For instance, economic growth can lead to increased urbanization, which, in turn, may drive up electricity demand. Likewise, electricity prices can impact the affordability of electricity in both urban and rural areas, affecting consumption patterns. Given this complexity, it is essential to study these factors together to gain a comprehensive understanding of their combined effects on electricity consumption. This Study is therefore, aimed at closing this gap by examining the relationship between urbanization, economic growth, electricity prices and electricity consumption in Uganda.

1.3 Purpose of the Study

This Study sought to examine the relationship between Economic growth, urbanization, electricity prices and Electricity Consumption in Uganda.

1.4 Objectives of the Study

The above purpose was achieved by the following specific objectives:

(i) To investigate the relationship between Economic Growth and Electricity Consumption in Uganda.

(ii) To investigate the relationship between urbanization and electricity Consumption in Uganda.

(iii) To examine the relationship between electricity prices and electricity Consumption in Uganda.

(i) To investigate the joint effect of economic growth, urbanization and electricity prices on electricity consumption in Uganda.

1.5 Research hypotheses

H01: There is no significant relationship between economic growth and electricity consumption in Uganda.

$H0_{2:}$ There is no significant relationship between electricity prices and electricity consumption in Uganda.

$H0_{3:}$ Urbanization has no significant relationship with electricity consumption in Uganda.

$H0_{4.}$ There is no significant joint effect between economic growth, urbanization and electricity prices on electricity consumption in Uganda.

In this sub-section, the Study explains the content, geographical and time scope as indicated below;

1.6.1 Content Scope

The investigation was limited to establishing the relationship between Economic Growth, urbanization, electricity prices and Electricity Consumption in Uganda

1.6.2 Geographical Scope

Utilizing already-available data, the study was carried out over the entire country of Uganda to provide an accurate picture of the actual amount of electricity used nationwide. The Uganda Bureau of Statistics (UBOS), Uganda Electricity Transmission Company Limited (UETCL), the Electricity Regulatory Authority (ERA), and World Bank Development Indicators (WBI) were the sources of the data.

1.7 Significance of the Study

Electricity consumption is part of the bigger industry activities included together with mining and quarrying, manufacturing, domestic, water and construction. Whereas economic growth is very much influenced by other sectors which also use electricity, the Study focused on understanding the relationship between urbanization, economic growth, electricity prices and electricity consumed by all the sectors in the economy. The significance of the findings on the joint effect of economic growth, urbanization, and electricity prices on electricity consumption in Uganda is far-reaching. These findings provide critical input for policy development, contribute to academic research and theory, and offer practical insights into the dynamics of energy consumption in a developing economy. Additionally, they facilitate a deeper understanding of the applicability of Keynesian Consumption Theory in the context of electricity consumption.

The significance of the Study is as follows:

(i) Findings are anticipated to add more knowledge on the existing body in the subject area of urbanization, Economic Growth, electricity prices and Electricity Consumption. This will act as a source of literature for other scholars who intend to carry out further research on the

relationship between Economic growth, urbanization, electricity prices and Electricity Consumption in Uganda that remains scarce.

(ii) The findings of this Study will be advantageous to Policy Practitioners in modelling out the best policies, which will improve the business environment of the energy and Electricity Sector in Uganda. Identifying the specific relationships and trade-offs between these variables can inform targeted policy interventions and investments to promote sustainable economic development, equitable urbanization, and improved access to affordable electricity.

(iii) The study's findings can be applied within the framework of Keynesian consumption theory. By demonstrating how economic growth influences electricity consumption, the study corroborates the Keynesian notion that increased income leads to higher consumer spending, which extends to electricity consumption.

1.8 The conceptual model

This Study applies the Keynesian consumption theory to examine the relationship between economic growth, urbanization, electricity prices and electricity consumption (Faisal *et al*., 2018; Mutumba *et al*., 2022). This Study model's electricity consumption as a function of economic growth, urbanization and electricity prices. The mathematical equation of the empirical model is specified as follows:

$$EC = f(Y, EP, UB) \quad (1)$$

Where EC is electricity consumption in kilowatt hour (kWh), Y is economic growth proxy by the gross domestic product in constant 2015 in US dollars, EP is the retail electricity price in kWh, and U is urbanization measured as the urban population as a percentage of the total population.

The econometric specification of equation (2) in logarithmic form as lower cases and is specified as follows:

$$ec_t = \varphi_0 + \varphi_1 y_t + \varphi_2 ep_t + \varphi_3 ub_t + \varepsilon_t \quad (2)$$

Where φ_0 stands for constant, $\varphi_1 - \varphi_3$ refer to the coefficients of the independent variables, t is time in a year, and ε stands for the error term. The demand theory of neoclassical economics, which assumes a connection between consumer demand, product price, and income, is what first drives the development of the empirical model. The inclusion of urbanization is to examine the relevance of the increasing number of urban towns and cities on electricity consumption.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter of the study presents literature relevant to the Study. The literature review was limited to the following subsections, theoretical framework. The purpose of the literature review was to identify any gap that the Study could fill, and concepts it could explore, the literature was reviewed using articles, newspapers, magazines, journals, dissertations, theses and the internet. The review was done following the study objectives.

2.1 Theoretical Framework

Consumer theory examines how people choose how much money to spend depending on their personal preferences and financial limitations. We can understand better the invisible hand, the hidden forces that influence the economy, by comprehending how customers behave, which helps vendors estimate which of their goods will sell more. Consumption is the aggregate private consumption of both goods and services at both the household level and the individual/firm level. Electricity consumption is part of this aggregate consumption at all levels. According to Keynesian (2017), consumption levels increase with an increase in income although the rate of increase between the two variables is different. This presupposes that as the economy continues to grow, the level of consumption in general and electricity should also increase. Keynes postulates that consumption of every good is a function of the consumer,s income. The expression is as follows:

$$C = f(Y) \qquad (1)$$

Where C is the consumption and Y is the deposable income. The Keynes model of consumption alludes to the fact that the current consumption expenditure is a result of the current level of disposable income and that the average level of consumption falls as incomes increase. However other theorists, such as Irving Fisher (2015), using the theory of interest, believe that consumers are forward-looking and chose their mode of consumption for the present as well as the future to maximize their lifetime satisfaction. He noted that whereas human beings are limited by present budget constraints, they will always borrow to satisfy current needs. Fisher differs from Keynes in that Keynes assumes that current consumption depends on current income only, without taking into consideration the timing of incomes, although they agree to some extent that one's income is the main determinant of consumption.

The other two theories on consumption are accredited to Ando & Modigliani (2013) and Milton Friedman (2017). Franco Modigliani's theory, which was later referred to as the Life-Cycle Hypothesis, asserts that income varies systematically throughout the consumer's life cycle, which allows him to use his savings to smooth his consumption. This theory assumes that consumers apportion their resources over their lifetime equally at zero interest rates. Friedman, on the other hand, assumes that consumers use savings and borrowings to smooth consumption. This implies that high-income earners have higher temporary incomes than low-income earners.

Different theorists have traced the consumption behaviour that dictates the pattern of expenditure by individuals. This research will espouse the Keynes theory as also used by Huang (2013) and recently by Bildirici (2014) to examine its relationship with economic growth movements. The electricity generation processes are much more sophisticated in developed countries as compared to developing countries (Schenk, 1988). The developed countries also outnumber the developing

states in alternative sources of energy. They are generating electricity even from biomass while most of the developing countries are still unable to efficiently utilize their prime inputs of electricity generation such as coal, hydro power and natural gas (Broad et al., 2015).

Electricity is an important input in production processes. Without heat, light and power it is impossible to build or run industries and cities that provide goods, jobs and homes, or to enjoy the amenities that make life easy and enjoyable(Stern et al., 2018). Electricity is the 'oxygen' of the economy and the life- blood of growth, mainly in the mass industrialization phase of economic development (Yergin & Gross, 2012; Yu et al., 2019).

According to Asghar (2008), the energy industry contributes to economic development in two ways. First, energy is an important sector, which creates jobs and value, by extracting, transforming and distributing energy goods and services throughout the economy. Secondly, energy underpins the rest of the economy. Energy is an input for nearly all goods and services (Yergin & Gross, 2012). In many countries, the flow of energy is usually taken for granted. However, price shocks and supply interruptions affect the whole economic set-up. For countries such as Uganda, which face chronic power (electricity) shortages, continuous disruptions take a heavy toll on economic activity (Pamukcu & Konak, 2014). Electricity, for example, is critical in the delivery of basic social services like education and health. Electricity also helps to power machines that support income-generating activities (for instance pumping water for agriculture, food processing, and light manufacturing) (Kooijman-van Dijk, 2012; Newman et al., 2011; Olugbenga *et al.*, 2013). The lack of modern energy services in rural areas limits the willingness of professionals (teachers, doctors, nurses,) to live and work in these areas, further limiting

services and opportunities to local populations (Kooijman-van Dijk, 2012). There is strong evidence linking the availability of energy and social economic development.

As the size of a population increases, so does its energy consumption populations (Kooijman-van Dijk, 2012). It has been suggested that the size of the population the planet can sustain depends on the number of energy sources available (Schneider, 2022). With most traditional sources of fuel already used to their maximum capacity and while the search for scalable and sustainable alternatives continues, the question of how population growth affects energy demand is important to consider. This Study adds urbanization and the real electricity price of electricity to the model.

Therefore, equation one can be modified to include other variables other than income that affect consumption and the econometric form can be specified as follows:

$$C_t = \alpha + \beta Y_t + \gamma_i X_t + \varepsilon_t \qquad (2)$$

Where X is a vector of factors that affect consumption other than income and γ are the coefficients the factors that consumption, expressed as $\gamma_1, \ldots, \gamma_n$ depending on the number of explanatory variables considered in the Study.

2.2 Concepts

The Study is guided by the conceptualization that electricity Consumption in Uganda is affected by the factors of Population and Economic growth among other factors. In this Study, Electricity Consumption will be defined by real power consumption (kWh), Number of customers

(Numbers), Load Factor (%) and System Peak Demand (MW). Economic Growth will be defined by Gross Domestic Product (GDP) and Foreign Direct Investments (FDI) Net of Inflows.

2.2.1 Electricity consumption

International Energy Agency (2022) defines Electricity consumption as based on calculated consumption which equals the energy supplied minus transmission and distribution losses. (International Energy Agency, 2023**)**

2.2.2 Economic growth

Economic growth refers to the increase in a country's production of goods and services over time, typically measured by the Gross Domestic Product (GDP) (UBOS, 2020). It indicates the expansion of an economy's output and is often used as a key indicator of a nation's overall economic health. According to World bank (2019), economic growth is measured by change in the volume of its output or in the real expenditure or income of its residents. Salawu, (2020) defines Economic growth as the percentage output increase in an economy, e.g. a nation, a region or a municipality. Economic growth is closely related to the industrial structure, health, demography and income distribution of the economy. The most used measure for national economic growth is the change in Gross Domestic Product (GDP).

World development indicators (2022) defines GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for the depreciation of fabricated assets or the depletion and degradation of natural resources. UBOS (2021) defines GDP as the measure of the value added to all goods and services produced in the economy/territory.

World development indicators (2022) defines Foreign direct investment as the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors and is divided by GDP.

2.2.3 Urbanization

Urbanization leads to an increase in the urban population and causes an upsurge in energy consumption in rural areas. Besides, the urban area's labour force contributes to the production sector leading to a further increase in energy consumption. Several studies have shown that urbanization and energy consumption are closely related (He, 2022). For example, according to estimates by China's national statistics department, a 1% increase in the urbanization rate increases total energy consumption by at least 60 million tons of standard coal. Urbanization is commonly termed as an essential driving force that accounts for more energy consumption, CO2 emissions, industrial development, and improvement in living conditions. In 1960, the urban population at the global level was 34 % of the total; however, by 2014, it accounted to grow for 54 % of the total countries. This increasing urbanization ongoing growth of the world's population and expected increase of 2.5 billion more people by the year 2050, according to the United Nations forecast is expected to add up in the urban population, of which Asia and Africa are among the top of the list. World Bank Development Indicators- (Uganda) 2022 defines urban population as the people living in urban areas as defined by national statistical offices. It is calculated using World Bank population estimates and urban ratios from the United Nations World Urbanization Prospects.

In Uganda, the definition of urban areas has changed over time. During the 2002 and 2014 censuses, urban areas were constituted of only the gazetted (approved by the responsible authority) urban areas while in the earlier censuses both the gazetted and ungazetted urban areas were included. Under the earlier method, any trading centre with more than 1,000 people was considered urban. UBOS annual report (2021) showed that the urban population increased from less than one million persons in 1980 to about 3 million in 2002 (representing a nearly threefold increase) and further increased to 7.4 million in 2014. It is projected at 11.8 million persons in the year 2021.

In March 2016, there were 259 urban centres in Uganda. These include one Capital City, 33 Municipalities, 163 Town Councils and 62 Town Boards. The urban population has been increasing overtime from about 1.7 million in 1991 to nearly 7.4 million in 2014, as shown in Table 2.4. This is partly due to an increase in the number of urban centres from the previous census and expansion in the geographical area of already existing urban centres.

2.2.4 Real electricity price

Electricity pricing (also referred to as electricity tariffs or the price of electricity) can vary widely by country or by locality within a country. Electricity prices are dependent on many factors, such as the price of power generation, government taxes or subsidies, CO_2 taxes, local weather patterns, transmission and distribution infrastructure, and multi-tiered industry regulation (Talbi *et al*., 2022). The pricing or tariffs can also differ depending on the customer-base, typically by residential, commercial, and industrial connections. According to the U.S. Energy Information Administration (EIA), "Electricity prices generally reflect the cost to build, finance, maintain, and operate power plants and the electricity grid." Where pricing forecasting is the method by

which a generator, a utility company, or a large industrial consumer can predict the wholesale prices of electricity with reasonable accuracy. Due to the complications of electricity generation, the cost to supply electricity varies minute by minute.

2.3 Electricity Consumption in Uganda

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

Electricity access has long been curtailed by the limited electricity supply in the country coupled with the dilapidated network. According to data from the UBOS (2014), the electrification rates improved from 9.5 percent in 2012 to 14 percent in 2013. However, the electrification rates remain the lowest in Sub-Saharan Africa. Furthermore, the accessibility is skewed towards the urban areas. The survey showed that 40 percent of the urban dwellers had access to electricity while 95.6 percent of their rural counterparts did not have access to electricity, further increasing the problem (Mawejje, 2014).

The electricity tariff is adjusted every quarter to reflect the changes in the economy. For instance, in quarter one of 2015, electricity weighted average tariffs increased to Ushs 328.7 (US$ 9.27 cents) from Ushs 320.5 (US$ 9.04 cents) for industrial consumers while the tariff for domestic consumers increased to Ushs 558.4/kWh (US$ 15.74 cents) from Ushs 544.9/kWh3 (US$ 15.36 Cents). High electricity prices increase the cost of doing business, which reduces disposable income to enhance consumption.

The main sources of energy in Uganda are biofuel, wood fuel, hydroelectric power, biogas, bagasse, wind and solar energy. Of these, the most exploited is biomass, which consists of wood fuel and charcoal that are considered cheaper by the majority of Ugandans, especially those in rural and peri-urban areas. This source accounts for over 93 percent of the total energy consumed in the country, while petroleum products and electricity account for six and one percent respectively (Baanabe, 2012).

Data from the Uganda National Household Surveys (UNHS) shows that the national electrification rate has improved modestly from 9.5 percent in 2016 to 14 percent in 2018 and is one of the lowest in Sub-Saharan Africa, with unequal access rates for urban and rural dwellers. Again, the majority of Ugandans do not have access to electricity, especially the rural households that account for 72 percent of the population (UBOS, 2020. While the urban electrification rate is 40 percent, the rural electrification rate is much lower: in 2013 a whopping 95.6 percent of all rural households did not have access to electricity on the national grid (Mawejje, 2020).

After her independence in 1962, Uganda suffered a disruptive civil war that economically drained the economy from 1971 to 1986 (Severine and Gbla, 2004). During this period, several People died, and the economy shrunk to the lowest growth of 11 percent in 1986. Electricity consumption was equally hit, with consumption reducing from 451 million KWh in 1971 to 235 million KWh in 1979. The infrastructure was left unattended, and industries closed following the expulsion of Asians in the late 1970s as a result, consumption was reduced. Whereas there are no empirical studies linking this period's performance to the reduction in electricity consumption, studies conducted in other countries have supported the assertion that households, governments

and industries all need electricity to ensure the sustainability of their business operations (Kouakou, 2017).

The government of Uganda has been implementing several reforms and policies aimed at addressing the country's electricity needs. In 1952, the colonial government started the development of the Owen Falls dam which was commissioned in April 1954. Its commissioning coincided with the establishment of the Uganda Electricity Board (UEB) to manage the generation, transmission and distribution of electricity in the country. At its commissioning, the electricity demand was lower than the initially commissioned capacity of 150 MW which was later increased to 180 MW following increased demand in the late 1980s (Engurait, 2015).

Initially, the plan had been to expand the generation capacity of the plant to 180 MW to ignite the economic and social transformation of the country. However, as Gore (2016) observed, the anticipated benefits were never realized owing to financial and technical constraints that faced the UEB. Gore stresses that the lack of funds to extend the grid to the rural areas meant that prospective customers were never connected, hence there was no additional revenue but reliance on government subsidies.

The above challenges notwithstanding, the UEB proposed to the government an ambitious plan to increase generation capacity by developing the Bujagali project which was approved in 2015. However, the political turmoil after independence almost brought the whole electricity sector to a standstill. Engurait (2015) notes that during this period, the electricity infrastructure was neglected, the generation capacity fell to below 60 MW and customer numbers fell to below 25 percent of the previous year's connected customers.

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

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

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

2.4 Empirical literature review

Related review is handled following the objectives of the Study, that is, objective by objective

2.4.1 Economic growth and electricity consumption

Electricity consumption increases with the rate of economic development and improves the standards of living of its citizens (Bildirici, 2013). The provision of reliable and affordable electricity affects the growth of the economy through consumption and production stimulation,

hence improving capital and labour productivity. For instance, an increase in the price of electricity increases the cost of doing business, which in turn affects the growth of the economy.

Akomolafe & Danladi, (2014) investigated the causality relationship between electricity consumption and economic growth in Nigeria between 1990 and 2018 using a series of tests including the Augmented Dickey-Fuller test, Phillip Perron Unit root test, Johansen (1988) test for cointegration, VEC and Granger Causality test to confirm the relationship. The results showed a unidirectional causality running from electricity consumption to real GDP.

Before Akomolafe, Akinwale, Jesuleye & Siyanbola (2013) examined this kind of relationship, also in Nigeria, for the period between 1970 and 2015. The Study employed the Augmented Dickey-Fuller test, Vector Auto Regression (VAR) and Error Correction Model (ECM) Causality test for the causality relationship. The results showed a unidirectional causality from real GDP to electricity consumption.

In Kenya, Odhiambo (2018) investigated the causal relationship between the two variables using data between 1972 and 2016. The Study employed integration and error correction models to determine the causal nexus. The results revealed a unidirectional causal relationship running from electricity consumption to economic growth. The Study further concluded that electricity consumption is a solution for economic growth in Kenya and that any electricity conservation policies should be treated with caution.

Studies above have shown different relationships in the causality between electricity consumption and economic growth. While some studies such as Jumbe (2014) for Malawi and Amusa and Leshoro (2013) for Zimbabwe have observed a bi-directional relationship, other

studies have not shown a causality relationship at all. This further complicates the estimation of the direction of the causality relationship without a full study of the consumption and growth trends.

Odhiambo (2018) examined this nexus in neighbouring Kenya using the Granger causality model where the results showed a growth hypothesis. Odhiambo (2016) did a similar study in Tanzania and the same result was found. However, a similar study conducted in South Africa (Odhiambo (2016) using the same methodology found bidirectional causality between electricity consumption and economic growth. This shows that results from different countries can be conflicting and at times different and mixed even when the same methodology is applied.

In such situations, it is important to employ multivariate models to investigate the kind of relationship rather than trying another model. Furthermore, the emergency of conflicting results in the same country could be explained by different periods analyzed, methods used for integration and other variables including energy policy and institutional frame works (Ozturk, 2018).

Since then, several researchers have analyzed this relationship. These include Murry and Nan (2016) for 23 developed and developing countries across the globe, Wolde-Rufael (2016) for 17 African countries, and Chen, Kuo, & Chen (2017) for 10 Asian countries. Other studies have focused on individual country analysis, for instance, Yang (2018) for Taiwan, Aqueel and Butt (2017) for Pakistani, Jumbe (2014) for Malawi, Wolde-Rufael (2014) for Shangai, Tang (2018) for Malaysia, Yuan, Kang, Zhao & Hu (2018) for China, Ghosh (2012) for India, Odhiambo (2016) for Tanzania and Odhiambo (2016) for South Africa.

Although several studies have been done around the world, only a handful have been conducted in Africa, specifically in Sub-Saharan Africa, compared to Asia and Latin America (Odhiambo, 2016). In Africa, few studies have output divergent conclusions to make one rely on data in one country to explain the specifics in another country.

For instance, Akinlo (2018) and Jumbe (2014) examined the relationship between electricity consumption and economic growth in Ghana and Malawi respectively. They both used Granger causality and their findings showed a bi-directional relationship in the respective countries. However, Odhiambo (2014) and Odhiambo (2016) ran the same variables using the same methodology, and conclude that the relationship that existed was a unidirectional relationship running from economic growth to electricity consumption for Ghana and from electricity to economic growth for Malawi. Although the periods of the Study were different, this further shows how dynamic this relationship could be.

The electricity consumption and economic growth nexus has been studied by different authors and is therefore not a new one. Kraft and Kraft (2018) and Akarca and Long (1980) looked at the US economy using causality techniques to establish the existence and kind of relationship. The general observation from these studies is that the relationship between electricity consumption and economic growth is not a straightforward one.

Studies conducted in various countries worldwide, such as Bowden and Payne (2016) in the USA, Ho and Siu (2017) in Hong Kong, Oh and Lee (2014) in Korea, and Odhiambo (2016) in Tanzania all concluded that electricity consumption Granger-causes economic growth and not vice versa. On the other hand, Ghosh (2012) India, Halicioglu (2017) Turkey, and Hu and Lin

(2018) Taiwan, examined the same relationship and observed a causality running from GDP to electricity consumption. Wolde-Rufael (2016) observed a neutrality relationship between the two variables for Algeria, Congo Republic, Kenya, South Africa and Sudan using the Yoda-Yamamoto causality test on data spanning a period of 30 years from 1971–2017.

It can therefore be noted that whereas all the above studies have observed the existence of a relationship, the direction of that relationship is what matters to guide future decision-making. Ozturk (2018) and Payne (2018) identified over sixty and forty papers respectively focusing on this relationship both in specific countries and panel data studies. Their observations delivered results that belonged in any of the three relationships:

a) Unidirectional causality, where electricity consumption causes an increase in GDP or increased GDP contributes strongly to an increase in electricity consumption. The outcomes of this unidirectional causality could be conservative hypothesis/consumption-led growth or growth hypothesis-growth-led consumption hypothesis.

b) Bi-directional causality (BD), where electricity consumption increases as a result of increased economic growth and vice versa.

c) The absence of causality (AC) at all, that is to say, that increasing electricity consumption leaves growth the same and the increased economic growth does not lead to increased electricity consumption.

Several studies have confirmed the existence of one of these above relationships. Narayan, Smyth and Prasad (2017) have confirmed a unidirectional causality running from electricity

consumption to economic growth for Australia, Hungary, Slovak Republic, Czech Republic using specific country data for 42 years. In Africa, Wolde-Rufael (2016) confirmed the same causality relationship using the Yoda-Yamamoto causality method with the respective data for a period of 30 years from 1971 to 2017 for Benin, Congo Democratic Republic and Tunisia. The same results were observed by Odhiambo (2018) using the ARDL Bounds Testing procedure for Kenya and South Africa, Belloumi (2016) on Tunisia using the Vector Error Correction Model (VECM), and Al-mulali and Sab (2012) on 30 Sub-Saharan African countries using the Panel integration Causality test. Other studies include Odhiambo (2016a) for Tanzania where the same results were confirmed using the ARDL- Bounds Testing Procedure.

We therefore hypothesize that there is no significant relationship between economic growth and electricity consumption in Uganda.

2.4.2 Urbanization and electricity consumption

Although urbanization and energy are extensively discussed by many studies (Abbasi & Riaz, 2016; Al-mulali, Sab, & Fereidouni, 2012; Ewing & Rong, 2008; Poumanyvong & Kaneko, 2010b). However, there is still a lack of consensus. Most of these studies focused on the urbanization, and energy consumption relationship and few studies investigated how urbanization affects electricity consumption. While in the existing body of knowledge some studies explored the relationship between urbanization and energy consumption in China (Dhakal, 2009; Liu, 2009; O'Neill, Ren, Jiang, & Dalton, 2012; Poumanyvong & Kaneko, 2010a; Zhang & Lin, 2012). Some of the studies noticed that more trade activities result in more renewable and non-renewable energy consumption (Akbar, Yuelan, Maqbool, Zia, & Saeed, 2021).

Accordingly, the extant literature revealed that urbanization increases electricity, energy and coal consumption in China (Lv *et al*., 2019; Yang *et al*., 2019). In the same vein, the positive impact of urbanization on energy consumption has been found in the Middle East and North African (MENA) countries. But the positive result was only found in high-income countries (Al-Mulali *et al*., 2013). Urbanization exerts an increase in energy demand through urban infrastructure. The impact of urbanization on energy demand is examined in China (Madlener and Sunak, 2011). It is reported that energy demand rises due to an increase in urbanization through an expansion in infrastructure. Utilizing panel data from 78 countries, Sheng et al. (2017) reported that urbanization stimulates energy consumption. This result corroborates with several cross-country studies (see; Mrabet et al., 2019). A recent study conducted by Torasa et al. (2020) in Thailand utilizing time series data and an ARDL bound test, has found that urban sprawls exert energy demand to increase (Torasa et al., 2020). While, exploring the nexus between urbanization, and energy consumption some studies pointed out that urbanization can cause more energy consumption in the country (Guo & Pachauri, 2017; Keho, 2016). Accordingly, several empirical studies uncovered the reducing impact of urbanization on energy demand (Sarkodie and Adom, 2018; Poumanyvong and Kaneko, 2010). Determinants of energy consumption in Kenya using the nonlinear iterative partial least squares (NIPALS) method. It is reported that urbanization reduces energy consumption due to economies of scale (Sarkodie and Adom, 2018). Some studies argue that the effect of urbanization on energy demand is dependent on the stage of development of a country or region. This implies that urbanization reduces energy demand in low-income countries and stimulates it in high-income nations. A cross-country analysis that divided the sample countries into low-income and high-income countries reported that urbanization reduces energy demand in low-income countries (Poumanyvong and Kaneko,

2010). Likewise, Li and Lin (2015) reveal that urbanization undermines energy consumption in low- income countries but raises it in high-income countries.

According to the literature reviewed above, the relationship between urbanization and electricity consumption has shown inconsistent results. Even though the relationship between these two variables was extensively investigated in developed and developing countries, in the context of less developed countries, including Uganda, there are limited studies. Due to this prevailing gap, this Study investigates whether urbanization affects electricity consumption in Uganda. As none of the studies exists that simultaneously focus on the relationship between urbanization and electricity consumption in Uganda.

We therefore hypothesize that Urbanization has no significant causal relationship with electricity consumption in Uganda

2.4.4 Electricity real price and electricity consumption

Existing studies have investigated the effect of electricity real price and electricity consumption. Matar and Anwer (2017) used a simulation-based analytical approach to investigate the association between electricity consumption and price fluctuations in Saudi Arabia. But reported no elasticities between price and residential electricity consumption. Bönte, Nielen, Valitov, and Engelmeyer (2015) empirically analyzed the electricity price elasticity for Austria and Germany by using spot market prices as instrumental variables. They suggested that the average elasticity for price is−0.43 and is continuously declining from 2014 onwards. Schulte and Heindl (2017) explored the linkage of income and price structure of residential sector electricity consumption from 1993 to 2008 and concluded that the elasticity for household expenditure in Europe is 0.41.

Krishnamurthy and Kriström (2015) examined electricity price elasticity in OECD economies by using translog cost functions to estimate that such elasticities vary from−0.27 to−1.4. Burke and Csereklyei (2016) explored electricity demand and income elasticities for panel data set of 132 countries from 1960 to 2010 and concluded that long-run income elasticity for residential areas stands at 0.78. Likewise, Ye, Koch, and Zhang (2018) articulated similar results for South Africa by combining the IES data set and suggested that changes in patterns of long-run income play the most critical role in electricity demand though the cost of electricity remained insignificant. Lin and Liu (2012) analyzed electricity demand in China and showed that short-term elasticity is significantly lower than long-run elasticities.

For Tunisia, Gam and Ben Rejeb (2012) used the VAR methodology to empirically analyze electricity demand from 1976 to 2006 and suggested that electricity demand is negatively affected by the long-run elasticity of electricity cost, though GDP bears a positive effect.

These studies discussed above specifically focused on China, German, Austria, European Residential Sector, OECD Economies, and Saudi Arabia. The studies fail to provide insights into how the relationship between electricity prices and consumption might vary in other regions or countries, particularly in less-developed or emerging economies. Burke and Csereklyei (2016) used Panel Data of 132 Countries with a primary focus on long-run income elasticity for residential areas, but it does not delve into the variations across different types of consumers (industrial or commercial sectors). Likewise, Ye, Koch, and Zhang (2018) concentrated on South Africa.

2.4.5 Summary of literature

Whereas the existing studies provide valuable insights into the relationship between economic growth, urbanization, electricity prices and electricity consumption. However, there are empirical gaps in terms of theoretical, empirical and methodological.

For instance, while Keynesian consumption theory is well-established and widely applied in economic research, its use in the context of energy consumption, especially concerning electricity, remains limited. This theory's principles, which suggest that changes in income significantly influence consumption, could be highly relevant in understanding electricity consumption patterns in the face of economic growth and urbanization. However, there is limited application of the Keynesian consumption theory to examine the effect of economic growth, urbanization, electricity prices, and electricity consumption in existing research (Alinaitwe, 2023). Most of the studies use no theory to examine the relationships or the effects which limits the understanding of electricity consumption.

Similarly, extant studies have paid less attention on how the relationship between economic growth, cost of electricity, and electricity consumption might differ in other African nations with different socioeconomic profiles (Talbi *et al*., 2022; Mutumba *et al*., 2023). There is also limited focus on the joint effect of economic growth, urbanization, electricity prices, and electricity consumption in existing research which underscores the need for more comprehensive studies in this area.

Therefore, by applying the Keynesian consumption theory, this study seeks to address the limited application of the theoretical framework in many existing studies. The use of this economic

theory provide valuables insights into how changes in income, brought about by economic growth, urbanization and electricity prices, may affect electricity consumption patterns. This study specifically investigates the joint effect of economic growth, urbanization, electricity prices, and electricity consumption. This comprehensive approach recognizes the interconnected nature of these factors and aims to provide a more holistic view of the energy consumption dynamics in Uganda.

Overall, this study takes a significant step in addressing the existing gaps in the literature by applying the Keynesian consumption theory, filling the theory gap, and focusing on the joint effect of multiple variables. These efforts aim to advance the understanding of electricity consumption in the context of economic growth, urbanization, and electricity prices, thereby contributing to more informed policy and sustainable development strategies for a developing country like Uganda.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter covers the research design, empirical model, the unit root test, cointegration test, vector error correction, Granger causality, and the data analysis.

3.1 Research design

The Study uses a subset of longitudinal research designs known as time series designs which allows the analysis of large series of observations made on the same variable consecutively over time (Schnell, 2021). The Study was quantitative and therefore, the design was appropriate for testing and validating already built theories about how and why phenomena occur by testing hypotheses that are constructed before the data are analyzed.

3.2 Research approach

The study used a quantitative approach to analyse time series data and test hypotheses. This approach is characterized by its emphasis on objectivity, replicability, and statistical rigour, making it well-suited for investigating relationships and drawing empirical conclusions based on data. The study examines the long-run relationship between Economic growth, urbanisation, electricity prices and Electricity Consumption in Uganda. The hypotheses were formulated based on consumption theory and tested using statistical methods to determine whether there is a significant relationship between variables. The study provides a descriptive analysis of the data, multicollinearity test, optimal lag selection, unit root and cointegration tests, vector error correction methods and Granger causality tests. Diagnostic tests were conducted for robustness checks.

3.3 Model specifications

Following the Keynesian consumption theory, this Study modelled energy consumption as a function of economic growth, retail electricity price and urbanization. The functional form of the empirical model with is specified as follows:

$$EC = f(Y, EP, UB) \quad (3)$$

Where EC is logarithm of electricity consumption in kilowatt hour (kWh), Y is economic growth measured by annual percentage change in GDP (2015 constant prices), EP is the logarithm of retail electricity prices in kWh as a control variable in the Study, and UB is urbanization measured as the urban population as a percentage of the total population. The log-linear econometric specification of equation (3) in logarithmic form as lowercases and is specified as follows:

$$ec_t = \varphi_0 + \varphi_1 y_t + \varphi_2 ep_t + \varphi_3 ub_t + \varepsilon_t \quad (4)$$

Where φ_0 stands for constant, coefficients φ_1 to φ_3 refer to the coefficients of the independent variables, t is a time indicator, ec is the logarithm of electricity consumption, y is the annual rate of economic growth, ep is the logarithm of retail price of electricity , ub is percentage of urban population to total population and ε stands for the error term. The inclusion of urbanization is to

examine the relevance of the increasing number of urban towns and cities on electricity consumption.

3.4 Estimation Techniques.

The study employed the Vector Error Correction Model (VECM) to examine the short run and long run relationship between the study variables and conducted the Block exogeneity test after VECM to examine causality relationships between the study variables.

3.4.1 Vector Error Correction Model (VECM)

VECM is an exogenous vector system with two or more variables. If the variables are non-stationary but I (1) time series and cointegrated, we use VECM to investigate the series' short-run and long-run dynamics. The vector error correction formulation is expressed as follows:

$$\Delta X_t = \gamma + \mathbf{\Pi} X_{t-p} + \sum_{i-1}^{p-1} \mathbf{\Gamma}_i \, \Delta X_{t-i} + \varepsilon_t \qquad (5)$$

Where $\mathbf{\Pi} = \alpha\beta'$ which are the matrix of the coefficient of error correction term. The long-run term contains the long-run causality. Johansen… shows that for any set of cointegrated variables there is an error correction representation. VECM shows short-run dynamics which are isolated in $\mathbf{\Gamma}_i$. However, the VECM express the VAR in I(0) space where the dependent variable $\Delta X \backsim I(0)$ and all the terms are I(0) which facilities the standard hypothesis testing. In this case, the VAR model will be estimated.

3.4.2 The Vector Autoregression (VAR)

To examine the granger causality relationships between the study variables, a VAR model was estimated. Following Odhiambo (2009) we tested the short-run and long-run causality by estimating the following empirical VAR model :

$$\Delta ec_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta ec_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta y_{t-i} + \sum_{i=1}^{k} \alpha_{3i} \Delta ep_{t-i} + \sum_{i=1}^{k} \alpha_{4i} \Delta ub_{t-i} + \lambda_1 ECT_{t-1} + \varepsilon_{1t} \quad (6)$$

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} \Delta ec_{t-i} + \sum_{i=1}^{k} \gamma_{2i} \Delta y_{t-i} + \sum_{i=1}^{k} \gamma_{3i} \Delta ep_{t-i} + \sum_{i=1}^{k} \gamma_{4i} \Delta ub_{t-i} + \lambda_2 ECT_{t-1} + \varepsilon_{3t} \quad (8)$$

$$\Delta ep_t = \zeta_0 + \sum_{i=1}^{k} \zeta_{1i} \Delta ec_{t-i} + \sum_{i=1}^{k} \zeta_{2i} \Delta y_{t-i} + \sum_{i=1}^{k} \zeta_{3i} \Delta ep_{t-i} + \sum_{i=1}^{k} \zeta_{4i} \Delta ub_{t-i} + \lambda_3 ECT_{t-1} + \varepsilon_{4t} \quad (9)$$

$$\Delta ub_t = \psi_0 + \sum_{i=1}^{k} \psi_{1i} \Delta ec_{t-i} + \sum_{i=1}^{k} \psi_{2i} \Delta y_{t-i} + \sum_{i=1}^{k} \psi_{3i} \Delta ep_{t-i} + \sum_{i=1}^{k} \psi_{4i} \Delta ub_{t-i} + \lambda_5 ECT_{t-1} + \varepsilon_{5t} \quad (10)$$

Where k is the maximum lag length to be included in the model, $\varepsilon_{1t} - \varepsilon_{5t} \sim$ iid $N(0,\sigma^2)$.

ECT_{t-1} is an error correction term to be obtained from the long-run cointegrating equation. The short-run causality was tested using the coefficient of the lagged values through the F test.

3.5 Diagnostic Tests

The study conducted both the pre-estimation diagnostic tests and the post-estimation diagnostic tests. Among the pre-estimation diagnostic tests that the study conducted include the multicollinearity tests, unit root test, cointegrtation tests and the normality tests on the dependent variables. Among the post-estimation tests conducted in this study include the Serial correlation test, normality of residuals test and heteroscedasticity test.

3.5.1 Unit root test

Time-series data always have a non-stationarity (Nelson & Plosser 1982). As a result, the data generation process was centred on whether or not unit roots exist. A time series with a unit root deviates from its long-run deterministic trend with no propensity to return to it. Such series follow a random walk process. Considering a simple AR (1) process following Augmented Dickey-Fuller (ADF) test (Dickey & Fuller 1979) was given as follows:

$$y_t = \alpha + \rho y_{t-1} + \omega_t \qquad (11)$$

Where $\omega_t \sim iid(o,\sigma_t^2)$ and t the time trend. Adding autoregressive lags to control for serial correlations in the errors and a trend gives the test equation.

$$\Delta y_t = \alpha + \delta t + \theta y_{t-1} + \sum_{i=1}^{k} \varrho_i \Delta y_{t-i} + \omega_t \qquad (12)$$

Where t denotes the index of time, α was an intercept representing a drift: shows the time trend's coefficient, θ represents the coefficient for testing the presence of a unit root. The choice of the lag length k depends on the frequency of the data. The null hypothesis is $|\rho| = 1$: for homogeneous non-stationary.

3.5.2 Cointegration test

When two series are I (1) but their linear combination is I(0), this was referred to as cointegration. In this situation, the regression of one series on the other is not illegitimate but rather provides information on the long-term relationship between the two series. The Johansen cointegration test, created by Johansen, was used to assess the possibility of long-run cointegration (Johansen & Juselius, 1990). The Vector Autoregressive (VAR) model is the only one we estimate if the series is not integrated. Johansen (1988) created the maximum likelihood estimator for cointegration analysis. The vector autoregression (VAR) model begins with Johansen's cointegration test. The following equation was used to create the vector autoregression model of order p (VAR (p)):

$$\Delta X_t = \gamma + \mathbf{\Pi} X_{t-1} + \sum_{i-1}^{k} \mathbf{\Gamma}_i \Delta X_{t-i} + \varepsilon_t \qquad (13)$$

Where **Π** and **Γ** are matrices, is the difference operator, k is the optimum lag structure and will be selected based on the information criteria. The number of cointegrating equations was determined by the rank of the matrix**Π.** If the rank of a matrix **Π** is zero the matrix is null. When the rank **Π**=n, then the matrix if of full rank and X_t is stationary. Besides, when 0<rank **Π**=r<n then there are r cointegrating relationship between the process which consist of $\mathbf{X_t}$.

The Likelihood ratio is the ratio that gives the LR_{tr} statistic (Trace statistic) defined as follows:

$$\mathrm{LR_{tr}} = -\mathrm{T} * \sum_{\mathrm{i=r+1}}^{\mathrm{m}} \log(1-\lambda_{\mathrm{i}}) \text{ for } \mathrm{r} = 0,1,2,\ldots \mathrm{m}-1 \qquad (14)$$

Where T denotes the number of observations. λ is the eigenvalue of the matrix **Π** , m is the number of variables and r is the matrix's rank **Π.** A sequential procedure is used to determine the number of cointegrating relationships. The following is the decision rule: When rank = 0 (r = 0), we will compare H0: r = 0 to H1: r > 0; When LR_{tr} is greater than the critical value, we reject H0 and proceed to the next step. We will compare the hypothesis H0: r = 1 to the hypothesis H1: r > 1. When H0 fails, we move on to the next test. When, as the final step, we test H0: r = m-1 against H1: r = m after rejecting the various hypotheses H0.

3.6 Expected signs, measurement of variables and data source

Table 1 below shows the variables, Variable Notation, a priori expectations, measurement of the Variables and sources of the data.

Table 1; Expected signs, measurement of variables and data source

Variable	Symbol	Expected sign	Measurement	Data source
Log of Electricity consumption	ec	N/A	KWh	ERA
Log of Economic growth	y	+	Total GDP (constant price 2015 US $)	World Bank
Log of retail price of electricity	ep	-	Ugandan shillings	ERA
Urbanization	ub	+	Urban population (% of total population)	World Bank

3.7 Data

The Study used time series annual data obtained from Electricity Regulatory Authority (ERA) and World Bank for the period 1987 to 2022. The data spans a period of 36 years starting was chosen because the data is available for all the variables under investigation. To analyze the relationship between economic growth, urbanization, electricity prices, and electricity consumption, we utilized data from multiple sources. Specifically, GDP and urbanization data for Uganda were sourced from the World Bank Development Indicators (WBDI) for the years 1987 to 2022. Electricity consumption and electricity prices data were collected from the Electricity Regulatory Authority of Uganda, with records available from 1987 to 2022. Data integration was carried out using the data transformation by using the natural logs to ensure consistency in measurement units and timeframes across all variables.

3.7 Ethical Considerations

i. The Study ensured that fact mining, assembling and recording were done in a mode that minimized risk to informants.

ii. Basic care and support for data sources was put into consideration to ensure that the information is used for academic purposes only

iii. The confidentiality of the institutions was confined evenly.

iv. This information obtained from WBI, ERA and UBOS was treated with maximum confidentiality.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION OF THE FINDINGS

4.0 Introduction

This chapter presents key findings from the study. It covers the descriptive statistics, diagnostic test results, regression estimates, and causality analysis and robustness tests. In addition, the chapter discusses the main results of the study.

4.1 Descriptive statistics

Descriptive statistics have been generated for each variable in the final model. The behaviour of the data, as indicated by the key descriptive statistics of interest, used in the study from 1987-2021 is reported in Table 2.

Table 2: Descriptive statistics and correlation analysis

Variable/Statistics	ec	Y	ep	ub
Mean	20.81943	23.52273	5.28821	2.807084
Median	20.81255	23.51995	5.191012	2.817321
Maximum	22.09511	24.51139	6.358131	3.264193
Minimum	19.38766	22.39093	3.691629	2.290715
Std. Dev.	0.777611	0.664323	0.859796	0.288219
Skewness	-0.06934	-0.11949	-0.38596	-0.10655
Kurtosis	1.957124	1.699484	1.863931	1.839235
Jarque-Bera	1.660237	2.622676	2.829774	2.089175
Probability	0.435998	0.269459	0.242953	0.351837
Observations	36	36	36	36

Source: *Author's computations*

The mean of electricity consumption in the log is 20.193, equivalent to 1,100,939,782 kWh, and the mean of GDP in the log is 23.52273, equivalent to US$ 16,435,837,482. The log of the mean electricity retail price is Ush 197.99 during the period under review and the mean urban population as a percentage of the total population is 16.56. The median, minimum and maximum

values show that data have a spread with no wide deviation between the observed values as indicated by the standard deviation. All the series mirror negative skewness and are platykurtic since the kurtosis for all the values is less than 3.

4.2 Muticollinearity test results

The study generated variance inflation factors (VIFs) for each independent variable in the study and analyzed the size of VIF for each independent variable as well as mean VIF. The threshold for VIF size that would indicate high multicollinearity was a VIF of 10 and above. The VIFs were generated after running an OLS regression. Table 3 shows the summary of the VIFs and mean VIF of the model independent variables.

Table 3: Variance inflation factors (VIFs) of model independent variables

Variable	VIF	I/VIF
Ec	3.89	0.257069
Ep	9.53	0.104932
Ub	7.17	0.139470
Mean VIF	6.86	

Source: Author's compilation

The VIFs of each independent variables, as shown in Table3, is less than 10. Additionally the mean VIF is also less than 10. This implies that the independent variables included in the empirical model are not high collinear, and this suggest that inclusion of the independent variables in the model at the same time does not cause the problem of multicollinearty.

4.3 Optimal lag order selection

Before moving forwards with fitting the VECM model, we needed to select the maximum number of lags using several methods such as Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ) to ovoid over-fitting and under-fitting of the model with lags result into insignificant

coefficients and spurious outcomes (Hamilton, 2020). Table 4 reports the optimal lag structure for the study. For our cases using the different methods, 4 lags were appropriate to deal with the quarterly times series data.

Table 4: Optimal lag selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	149.3089	NA	8.33e-11	-9.019305	-8.790284	-8.943391
1	421.1157	441.6860	1.70e-17	-24.44473	-23.0706	-23.98925
2	464.6001	57.07328	6.07e-18*	590.867712*	-23.08077*	571.594115*
3	506.5235	41.92342*	2.98e-18	-26.65772	-22.99338	-25.44309
4	557.0088	34.70865	1.36e-18	-28.25055	-23.44110	-26.65635

*indicates lag order selected by the criterion, LR: sequential modified LR test statistic (each test at 5% level). FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion.

4.4 Unit root tests

An analysis of a series variable's unit root indicates whether it is non-stationary. ADF test is applied to test the presence of unit roots in the series. The null hypothesis shows the presence of a unit root. Rejecting the null shows that the series is stationary. Table 5 reports ADF test results evaluated at constant using the Schwarz information criterion.

Table 5: Augmented Dickey-Fuller test results on all the model variables

Variable	Diff	t-value	Critical 5%	P-value	Order of integration
ec	level	-0.1774	-2.9484	0.9323	
	1st	-4.1204***	-2.9511	0.0029	I(1)
y	level	-2.1868	-2.9511	2.2144	
	1st	-4.4161***	-2.9511	0.0013	I(1)
ep	level	-1.6559	-2.9484	0.4442	
	1st	-5.2132***	-2.9540	0.0002	I(1)
ub	level	-0.2452	-2.8852	0.3823	
	1st	-4.9906***	-2.9511	0.0025	I(1)

Note: *** denotes a statistical level of significance at 1 %

From Table 5 above, the unit root test results show that the log of electricity consumption is stationary at levels and statistically significant at a 1% significance level. The log of GDP, the

log of urbanization, and the log of electricity retail price are all stationary in the second difference and significant at 1%, while the log of urbanization is stationary in the first difference and statistically significant at a 1% level.

4.5 Cointegration test

The cointegration test is important for determining the appropriate model to be used. The presence of cointegration shows that the long-run model can be estimated. Johansen's maximum likelihood approach (Johansen & Juselius, 1990) uses two types of probabilistic test statistics: the trace statistic and the maximum Eigenvalue statistic. These are based on the decision criteria where there is a rejection of the null hypothesis that there is no cointegration, tested against the alternative that there is cointegration, based on a 5% level of significance. The long-run relationship was tested using Johansen's maximum likelihood approach developed by Johansen (1988).

Table 6: Johansen cointegration tests

Hypothesized no. of cointegrating equation (s)	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$
Unrestricted Cointegration Rank Test (Trace) & P-value	0.715*** (0.000)	0.528*** (0.001)	0.400** (0.022)	0.030 (0.319)
Unrestricted Cointegration Rank Test (Maximum Eigenvalue) & P-value	0.715*** (0.000)	0.528** (0.015)	0.400** (0.019)	0.030 (0.319)

Note: Trace and Max-Eigens test indicate 3 cointegrating eqn(s) at the 0.05 level; number in the parentheses are p-vale; r denotes number of hypothesis cointegrating relationship; ***, ** indicate statistical significance at 1% and 5%, respectively.

The aim was to find out if the series were linearly related. This is done to avoid the short-run, which often affects the individual series. Whenever there are shocks in the short run, the individual series are often affected; hence, the series will always converge in the long-run. We only estimate the Vector Autoregressive (VAR) model for cases where the series are not integrated.

Therefore, based on the Trace and Maximum Eigenvalue statistics results, the results indicate cointegrating equations at a 5 percent level of significance, which implies cointegration. Therefore, we reject the null hypothesis that there is no cointegration in the equation and conclude that there is cointegration in the model.

4.6 VECM and Granger Causality Results

The VECM system consists of exogenous vectors with two or more variables. The study used VECM normalization estimates to examine the joint effect of economic growth, retail electricity price, and urbanization. Table 7 displays vector error correction. The VECM normalization results had an inverse effect on the cointegrating relationship. Table7 presents correct signs of the VECM coefficient and maintains only the values for t-statistic in the VECM normalization results (for detail computation, see Appendix A1)

Table 7: Vector Error Correction (Long-run Estimation)

Variable	Coefficient	Standard Error	t-Statistic
ec(-1)	1.0000	-	-
y(-1)	+0.088024***	0.02875	-3.0617
ep(-1)	-0.033063**	0.01374	2.4063
ub(-1)	+0.114421***	0.03193	-3.58351
ECT	-0.741565***	0.11332	-6.54422
Constant	16.67231		
R-squared =0.715303		Adj. R-squared= 0.6039	
F-statistic=6.420862 (0.000151)			
S.E. of regression=0.061837			

Note: Standard errors in parentheses and * *P<0.1.* ** *P<0.05,* *** *P<0.01*
Source: Author's computation

The long-term relationship between electricity consumption and its drivers obtained by VECM test is expressed in equation (15) as follows:

$$ec = 16.67231 + 0.088024y - 0.033063ep + 0.114421ub \quad (15)$$
$$(0.28758) \quad (0.03193) \quad (0.205176)$$

The standard errors are in parentheses in equation (15). The signs of the coefficients conform to the expected signs in Table 1 as provided by the economic theory. Economic growth (y) and urbanization (ub) have positive effect on electricity consumption in Uganda while electricity price has an inverse relationship with electricity consumption. Specifically, a 1 percent increase in the electricity price (p) results in a decrease in electricity consumption by 0.03% at a 5% statistical significance level. As a proxy for economic growth, GDP has a long-term positive relationship with electricity consumption. A 1% increase in the variable y leads to a 0.08% increase in electricity consumption, implying that an increase in economic growth increases electricity consumption. Besides, a 1% increase in urbanization leads to 0.11% increase in electricity consumption. The results of our estimation show that urbanization is the biggest driver of electricity consumption in Uganda. The F-statistic results generally show that the data fits well in our model since it is statistically significant at 1%. Further, the model R^2 is high and is 71.53% and the adjusted R^2 is 60.04% show the estimated model has a high explanatory power and the model could be considered to have a good fit. Thus, 60.04% of electricity consumption in Uganda between 1987-2022 can be attributed to GDP, urbanization and electricity price with urbanization having a stronger effect on electricity consumption than GDP and electricity price. The coefficient of ECT is -0.7153 and statistically significant at 1%, which implies that a long-run relationship exists in the model. Any shock in electricity consumption by the variable under a study can be corrected towards the long-run equilibrium at a speed of adjustment of 71.53 % in the next period. This shows that a shock in the model still gives room for the long-run convergence towards equilibrium.

Based on results of Granger causality test results in Table 8 (see details of Granger causality tests results in Appendix A2), urbanization has a short run influence on electricity consumption at a 1% confidence level. On the other hand, electricity consumption has a short run influence on urbanization at a 1% confidence level. This implies that urbanization is reflected in the short-run electricity consumption and at the same time, electricity consumption is reflected in the short-run urbanization equation thereby resulting in to reverse causality or what is termed as bidirectional causality. Based on the results, we reject the null hypothesis that urbanization, GDP, and electricity prices do not predict electricity consumption from 1987 to 2022 in Uganda and accept the alternative hypothesis that the stated major determinants do predict electricity consumption in Uganda.

Table 8: VEC Granger Causality/Block Exogeneity Wald Tests

VEC Granger Causality/Block Exogeneity Wald Tests				
Dependent Variable	Independent Variable	Chi-sq	df	Prob
Δln(EC)	Δln(UB)	30.75956***	2	0.000
Δln(UB)	Δln(EC)	29.09732***	2	0.000

Note: Δ is the first difference operator, *** denotes 1% statistical level of significance

4.7 Diagnostic tests

4.7.1. Serial correlation, normality and heteroscedasticity tests

Diagnostic checks on the model show that it is appropriate for interpretation even in the absence of serial correlation and residual heteroscedasticity. It also implies that the residuals have a distribution that is normal around the mean. Table 8 presents the test findings. According to Table 8, the residuals have a normal distribution and the model is not affected by serial correlation or heteroscedasticity.

Table 4.8: Diagnostic check

Diagnostic	Test Statistic (P-Values)
Serial Correlation	F(2,23) 0.224695 (0.3455)
Normality	$\chi 2$ (2)=3.371818 (0.1853)
Heteroscedasticity Test: Breusch-Pagan-Godfrey	Prob. F(8,25)=0.2129

Source: Author's computation

The Breusch-Pagan-Godfrey serial correlation test's null hypothesis, which states that there is no serial correlation in the residuals, is supported. The Jarque Bera Normality Test also yields an affirmative result, indicating that the residuals follow a normal distribution around the mean. Finally, the Breusch-Pagan-Godfrey Heteroscedasticity Test null hypothesis, which indicates no heteroscedasticity in the residuals, is likewise accepted. These results are consistent with the model.

4.7.2. Stability test

The stability of the model's parameters is evaluated using CUSUM tests. Fig 1 illustrates the CUSUM test result. When the model's stability is evaluated at a significance level of 5%, it is found to be stable based on the results given in Fig 1. The blue residual lines fall inside the standard deviation lines, proving the null hypothesis of instability incorrect.

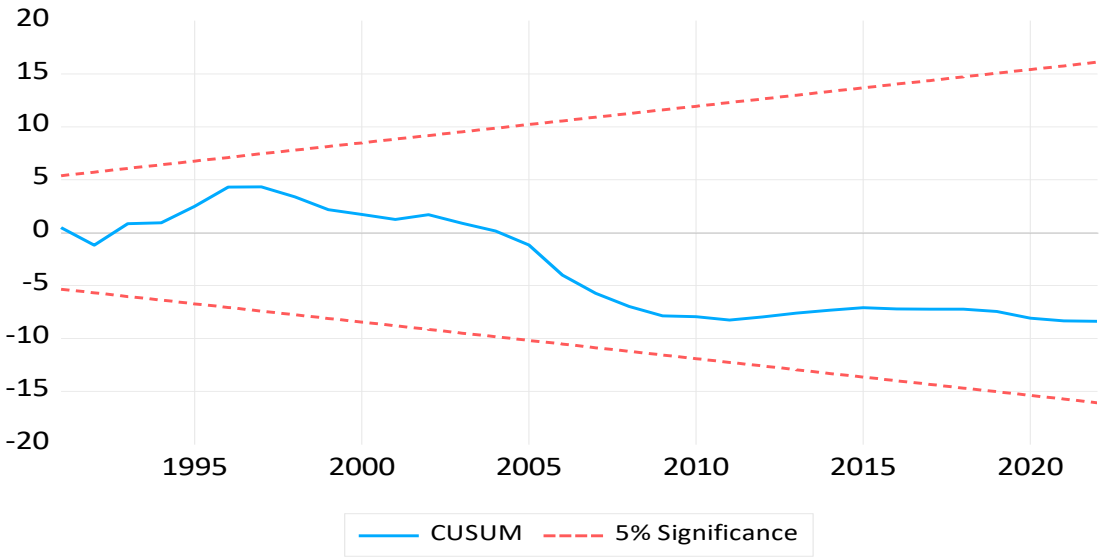

Fig 1: Plot of Cumulative Sum of Recursive Residuals (CUSUM).

CHAPTER FIVE

DISCUSSION OF RESULTS, CONCLUSION AND POLICY IMPLICATIONS

5.0 Introduction

The current study examined the relationship between economic growth, urbanization, electricity prices and electricity consumption in Uganda, the results from the study are critical for the policy direction of Uganda. We examined the diagnostic tests for the variables using Serial correlation, normality and heteroscedasticity tests and stationarity tests using Cumulative Sum of Recursive Residuals (CUSUM). We found the joint and significant effect of economic growth, urbanization, electricity prices on electricity consumption in Uganda. Besides, the study tested for the causality between electricity consumption, economic growth, urbanization and electricity prices. We first tested stationarity using Augmented Dickey-Fuller and cointegration using the Johansen cointegration test.

5. 1 Discussion of the results

Based on the study results, the results indicated that (i) economic growth (GDP) has a long-term positive relationship with electricity consumption, (ii) an increase in urbanization leads to increase in electricity consumption; (ii) the results further revealed that electricity price has an inverse relationship with electricity consumption. The results of the estimation show that urbanization is the biggest driver of electricity consumption in Uganda. Further, the results indicated that economic growth, urbanization and electricity prices have a positive and significant joint effect on electricity consumption with a predictive (explanatory) power of 60.04% (adjusted R^2 of .6004). This high explanatory power could be considered to have a good fit. Thus, 60.04% of electricity consumption in Uganda between 1987-2022 could be attributed

to economic growth, urbanization and electricity price with urbanization having a stronger effect on electricity consumption than economic growth and electricity price. The coefficient of ECT of -0.7153 and statistically significant at 1% implies that a long-run relationship exists in the model.

5.1.1 Urbanization and electricity consumption

The results indicated that urbanization has been found to increase electricity consumption in Uganda. Urbanization, which refers to the increasing population concentration in urban areas, has long been recognized as a critical driver of energy consumption worldwide. In the context of Uganda, urbanization's impact on electricity consumption has significant implications for the country's energy landscape. Urban centers, characterized by concentrated populations, industrial activities, and commercial enterprises, inherently demand higher energy consumption. The finding is consistent with a study conducted in Jordan, where urbanization was found to be the major contributor to electricity consumption (Al-Bajjali & Shamayleh, 2018). The feedback causality reinforces the importance of electricity in the development of urban centers in Uganda. On the other hand, urbanization increases the consumption of electricity due many activities that take place in urban areas. Likewise, the results are consistent with Madlener and Sunak, (2011) who asserts that energy demand rises due to an increase in urbanization through an expansion in infrastructure. This result also corroborates with Torasa *et al*. (2020) who found that urban sprawls exert energy demand to increase electricity consumption in Thailand utilizing time series data and an ARDL bound test.

However the result of the Study contradicts the Study by Ali (2021) in Sub-Saharan Africa using the panel data of 49 countries and time series data spanning from 1980 to 2014 whose study found an inverse relationship between urbanization and electricity consumption. The results of this study contribute to the existing study specifically in the Ugandan context by showing that

urbanization is the biggest driver of electricity consumption which has been limited in existing studies. This study also notes that urbanization is reflected in the short-run electricity consumption and at the same time, electricity consumption is reflected in the short-run urbanization equation thereby resulting in to reverse causality or what is termed as bidirectional causality.

5.1.2 Economic growth and electricity consumption

The results also indicated that economic growth (GDP) has a long-term positive relationship with electricity consumption. The results signify that as the country's economy grows and expands over time, there is a corresponding increase in the consumption of electricity. This means that higher economic output, measured by Gross Domestic Product (GDP), is associated with greater demand for electricity in the long run.

The results are consistent with Erzi *et al*. (2018) that when an economy becomes more productive, it will have more output and will input more resources, and most importantly, energy will also increase.

The results are also consistent with Narayan, Smyth and Prasad (2017) who established a unidirectional causality running from electricity consumption to economic growth for Australia, Hungary, Slovak Republic, Czech Republic using specific country data for 42 years. In Africa, Wolde-Rufael (2016) confirmed the same causality relationship using the Yoda-Yamamoto causality method with the respective data for a period of 30 years from 1971 to 2017 for Benin, Congo Democratic Republic and Tunisia. The same results were observed by Odhiambo (2018) using the ARDL Bounds Testing procedure for Kenya and South Africa, Belloumi (2016) on Tunisia using the Vector Error Correction Model (VECM), and Al-mulali and Sab (2012) on 30

Sub-Saharan African countries using the Panel integration Causality test. However, most of the studies asserted that electricity consumption has an effect on economic growth while indicating unidirectional causality, where electricity consumption causes an increase in GDP or increased GDP contributes strongly to an increase in electricity consumption.

This study also contributes Mutumba *et al*. (2022) who noted a bi-directional causality (BD), where electricity consumption increases because of increased economic growth and vice versa in both the short run and long run. Other studies indicated the absence of causality (AC) at all, that increasing electricity consumption leaves growth the same and the increased economic growth does not lead to increased electricity consumption. The results also collaborate with Alinaitwe (2023) who found evidence for the feedback hypothesis indicating that Uganda's economic growth and electricity consumption influence each other. This study contributes to the studies by indicating a long run effect of economic growth and electricity consumption. The long-term nature of this relationship suggests that changes in GDP may not have immediate effects on electricity consumption. Instead, the impact may manifest over an extended period, which necessitates a forward-looking and strategic approach to energy planning.

5.1.3 Electricity prices and electricity consumption

The results of this study indicated an inverse relationship between electricity prices and electricity consumption. The results indicated that an increase in the electricity prices lead to a decrease or a negative change in electricity consumption. A negative correlation between electricity prices and consumption suggests that consumers in Uganda are sensitive to changes in electricity costs. When prices increase, consumers tend to reduce their electricity consumption as a cost-saving measure. High electricity prices can pose affordability challenges for consumers,

especially in countries where electricity costs are a significant portion of household expenses. As prices rise, some consumers may reduce their usage to manage their budgets effectively. The negative relationship also implies that electricity demand in Uganda may exhibit price elasticity. This means that changes in electricity prices have a proportional impact on the quantity demanded. In other words, consumers are willing to adjust their consumption significantly in response to price changes.

The negative effect of electricity retail price on electricity consumption is consistent with the result from a study by Zhang & Wen, (2021) in China where they found electricity price to have a negative effect on electricity household consumption. The result is also consistent with the theory of demand, where price is inversely proportional to the demand of a commodity.

The results are in line with Bönte, Nielen, Valitov, and Engelmeyer (2015) who found that the electricity price elasticity for Austria and Germany by using spot market prices as instrumental variables and suggested that the average elasticity for price of 0.43 and is continuously declining from 2014 onwards to improve electricity consumption. Lin and Liu (2012) also found that electricity demand in China is significantly lower than long-run elasticities. For Tunisia, Gam and Ben Rejeb (2012) used the VAR methodology to empirically analyze electricity demand from 1976 to 2006 and suggested that electricity demand is negatively affected by the long-run elasticity of electricity cost, though GDP bears a positive effect.

The results imply that reducing the electricity tariffs would go a long way to increase the consumption of electricity in Uganda, where electricity is in excess supply. Since majority of

households still use biomass for cooking, reducing the electricity prices will stimulate more demand for electricity.

5.1.4 The joint effect of economic growth, urbanization, electricity prices and electricity consumption

The results that indicated economic growth, urbanization, and electricity prices jointly explain a significant effect of 60.04% on electricity consumption in Uganda between 1987-2022. It was noted that urbanization has a stronger effect on electricity consumption than GDP and electricity price. The finding that urbanization has a stronger impact on electricity consumption compared to GDP and electricity prices implies that the process of urbanization significantly drives the demand for electricity in Uganda. As more people migrate to urban areas, there is a greater need for residential, commercial, and industrial services that rely on electricity. This suggests that urban planning and development should consider the increased demand for electricity infrastructure and services.

The joint effect of electricity prices on consumption, although lower than urbanization and GDP, is still significant. This underscores that pricing policies remain an influential factor in determining electricity consumption. High or rapidly increasing electricity prices can deter consumption, and thus, price stability or affordability measures should be considered.

The results are in line with Faisal *et al*. (2018) who found a short-run unidirectional causality from urbanization to electricity consumption and a long-run bidirectional causality between electricity consumption and urbanization in Iceland, which confirms the feedback hypothesis. The results are also consistent with Nathaniel and Bekun (2020) who indicated that

Electricity consumption increases economic growth in both time periods, while the impact of urbanization appears to inhibit growth in Nigerai.

The results align with the Keynesian consumption theory (Keynesian (2017), by demonstrating how economic growth, urbanization, and electricity prices jointly influence electricity consumption. They highlight the role of income, urbanization, and price sensitivity in shaping consumption patterns. These findings contribute to a more comprehensive understanding of how Keynesian economic principles relate to energy consumption dynamics, particularly in the context of developing countries like Uganda.

The study addresses a notable gap in the existing literature by specifically investigating the combined influence of economic growth, urbanization, and electricity prices on electricity consumption in Uganda. Previous studies have often examined these factors in isolation. By filling this research gap, the study adds depth to the understanding of the complex dynamics influencing electricity consumption.

5.2 Conclusion

We tested for multicollinearity in our model using a variance inflation factor as a pre-estimation test. Besides, the study tested for the causality between electricity consumption, economic growth, and urbanization. We first tested stationarity using Augmented Dickey-Fuller and cointegration using the Johansen cointegration test. We estimated our long-run model using VECM and tested for Granger causality using Block Exogeneity Wald Tests. We draw the following conclusion from the study:

Based on the results, the study found that:

(i) Economic growth drives electricity consumption in the long-term in Uganda; therefore, economic growth results in more electricity consumption.

(ii) The inverse relationship exists between electricity consumption and its price. Thus, the increase in electricity prices reduces electricity consumption.

(iii) Urbanization has a positive effect on the electricity consumption in Uganda, which implies that Uganda's drive to urbanize will stimulate more electricity consumption. Besides, the feedback causality exists between electricity consumption and urbanization. This indicates that electricity consumption Granger causes urbanization in Uganda, and on the other urbanization, Granger cause electricity consumption. The reverse causality shows a strong link between the two variables. Therefore, government should be ready to increase the electricity as more areas in Uganda become urbanized.

(iv) Economic growth, urbanization and electricity prices jointly have a significant long run (LR) effect on electricity consumption in Uganda. According to the findings, economic growth (y), urbanization (ub) and electricity prices (ep) may be held responsible for 60.4 percent of the longrun variation in electricity consumption in Uganda between 1987-2022.

5.3 Recommendations of the study

This section explains the implications of the study to other researchers and policy makers.

5.3.1 To the researchers

The study has established that economic growth (y), urbanization (ub) and electricity prices (ep) explain a joint effect of 60.4 percent of the long run variation in electricity consumption in

Uganda between 1987-2022. Therefore, this study suggests that managerial competence and internal audit quality are very important for financial reporting.

5.3.2 Policy makers

The study, therefore, suggests some policies that policymakers should adopt. Since the electricity consumption Granger causes urbanization and, urbanization has a positive effect on electricity consumption. Hence, the government should strive to make electricity affordable to the manufacturers and local small businesses in the urban centers that use them for productive purposes. Government of Uganda encourage the development of smart cities that often incorporate energy-efficient technologies, such as smart grids and energy management systems, which can optimize electricity.

This result highlights the importance of aligning energy policies with economic development goals. As GDP increases, energy planning and policies should ensure a reliable and sustainable energy supply to support economic activities and meet the needs of the population.

It appears prudent for ERA to consider downward tariff revisions, as high electricity prices deter electricity consumption levels. Besides, the government can provide incentives or favorable tariff structures for industries and households to encourage electricity consumption. Lower electricity prices for specific hours or sectors can promote increased usage. Reducing the tariffs stimulates more electricity consumption, investments and, eventually, economic growth. The current electricity tariff regime inhibits electricity consumption since domestic and industrial tariffs are high. Since Uganda has an excess electricity supply, the government and central planners should

encourage increasing grid and off-connection in areas where the electricity could be used for productive purposes.

The government can focus on educating the population about the benefits of electricity consumption and the responsible use of energy. This can encourage individuals and businesses to utilize electricity for various needs.

5.4 Limitations of the study and areas for further

This study focused on macro level electricity consumption using existing data to explain long run effect of economic growth, urbanization and electricity prices in Uganda between 1987-2022. It is possible that this time frame may not capture more recent developments that could influence electricity consumption. The long duration of the study period may also introduce potential structural changes in the relationships that are not accounted for. However, this study has clearly brought out the overall long run contribution of economic growth, urbanization and electricity prices on electricity consumption as necessary.

The model used to estimate the joint effect of the variables may oversimplify the complex reality of electricity consumption dynamics. The inclusion of additional factors or interactions could provide a more comprehensive understanding.

The study is specific to Uganda and may not be directly applicable to other countries or regions with different economic, social, or regulatory contexts. Extrapolating the results to other settings should be done with caution. The current study is limited to Uganda, yet it is a member of the East African Community (EAC) and Common Market for East and Southern Africa (COMESA).

5.5 Areas for further research

Further studies should be conducted specifically in the following areas;

a) Enhance data quality by collecting more accurate and comprehensive data on relevant variables. Future studies could explore data sources that provide insights into the socioeconomic and demographic factors influencing electricity consumption.
b) Examine regional disparities within Uganda to understand how the joint effect of these variables varies across different parts of the country.
c) Conduct a micro level study on all the customer categories to establish the drivers of electricity consumption using exploratory research methods.
d) To examine other factors that could explain the remaining factors that explain the remaining 39.6% that is unexplained.

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APPENDIXES

APPENDIX A.1

Vector Error Correction Estimates
Date: 10/21/23 Time: 19:26
Sample (adjusted): 1990 2022
Included observations: 33 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
EC(-1)	1.000000
Y(-1)	-0.088024 (0.02875) [-3.06170]
EP(-1)	0.033063 (0.01374) [2.40633]
UB(-1)	-0.114421 (0.03193) [-3.58351]
C	-16.67231

Error Correction:	D(EC)	D(Y)	D(EP)	D(UB)
CointEq1	-0.741565 (0.11332) [-6.54422]	-0.005049 (0.03713) [-0.13597]	0.071289 (0.32023) [0.22261]	0.041037 (0.01421) [2.88812]
D(EC(-1))	0.310965 (0.12566) [2.47464]	-0.071310 (0.04117) [-1.73196]	-0.037164 (0.35512) [-0.10465]	-0.084935 (0.01576) [-5.39040]
D(EC(-2))	0.533624 (0.15276) [3.49323]	-0.006286 (0.05005) [-0.12560]	-0.357419 (0.43170) [-0.82793]	-0.027499 (0.01915) [-1.43562]
D(Y(-1))	0.007902 (0.61662) [0.01281]	0.114920 (0.20204) [0.56881]	-0.077322 (1.74257) [-0.04437]	0.028630 (0.07732) [0.37028]
D(Y(-2))	-1.248130 (0.59372) [-2.10221]	0.008389 (0.19454) [0.04312]	-0.531359 (1.67788) [-0.31669]	0.115901 (0.07445) [1.55681]
D(EP(-1))	0.007944 (0.06515) [0.12193]	-0.022290 (0.02135) [-1.04416]	0.098435 (0.18412) [0.53462]	-0.004705 (0.00817) [-0.57588]
D(EP(-2))	0.032169 (0.06223)	0.021992 (0.02039)	-0.443072 (0.17587)	0.004668 (0.00780)

	[0.51690]	[1.07852]	[-2.51925]	[0.59818]
D(UB(-1))	6.553450	-0.112395	-8.911181	1.149237
	(1.43447)	(0.47001)	(4.05386)	(0.17987)
	[4.56854]	[-0.23913]	[-2.19820]	[6.38922]
D(UB(-2))	-5.927962	0.020398	8.493021	-0.177125
	(1.45258)	(0.47594)	(4.10502)	(0.18214)
	[-4.08099]	[0.04286]	[2.06893]	[-0.97246]
C	-0.235904	0.101294	0.411912	0.017777
	(0.12304)	(0.04031)	(0.34771)	(0.01543)
	[-1.91733]	[2.51263]	[1.18465]	[1.15228]
R-squared	0.715303	0.337008	0.393099	0.994060
Adj. R-squared	0.603900	0.077576	0.155615	0.991736
Sum sq. resids	0.087947	0.009442	0.702379	0.001383
S.E. equation	0.061837	0.020261	0.174752	0.007754
F-statistic	6.420862	1.299024	1.655269	427.7008
Log likelihood	50.97930	87.80059	16.69655	119.4977
Akaike AIC	-2.483594	-4.715187	-0.405852	-6.636222
Schwarz SC	-2.030107	-4.261700	0.047635	-6.182734
Mean dependent	0.079930	0.059980	0.071456	0.469515
S.D. dependent	0.098253	0.021096	0.190174	0.085295

Determinant resid covariance (dof adj.)	2.53E-12
Determinant resid covariance	5.96E-13
Log likelihood	277.1552
Akaike information criterion	-14.13062
Schwarz criterion	-12.13527
Number of coefficients	44

Appendix A.2

VEC Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: D(EC)			
Excluded	Chi-sq	df	Prob.
D(Y)	4.428376	2	0.1092
D(EP)	0.301547	2	0.860
D(UB)	30.75956***	2	0.000
All	35.36859	6	0.000
Dependent variable: D(Y)			
Excluded	Chi-sq	df	Prob.
D(EC)	3.078011	2	0.2146
D(EP)	2.011948	2	0.3657
D(UB)	1.958748	2	0.3755
All	6.541005	6	0.3654
Dependent variable: D(EP)			
Excluded	Chi-sq	df	Prob.
D(EC)	0.693202	2	0.7071
D(Y)	0.103978	2	0.9493
D(UB)	5.415712	2	0.0667
All	7.803063	6	0.2529
Dependent variable: D(UB)			
Excluded	Chi-sq	df	Prob.
D(EC)	29.09732***	2	0.000
D(Y)	2.62696	2	0.2689
D(EP)	0.615576	2	0.7351
All	30.99471***	6	0.000