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DETERMINANTS OF RENEWABLE ENERGY CONSUMPTION

IN UGANDA

BY

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A RESEARCH REPORT SUBMITTED TO MAKERERE UNIVERSITY BUSINESS SCHOOL (FACULTY OF GRADUATE STUDIES AND RESEARCH) IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF ENERGY ECONOMICS AND GOVERNANCE OF MAKERERE UNIVERSITY

PLAN A

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DECLARATION

I declare that this research dissertation "Determinants of Renewable Energy Consumption in Uganda" is my original work and it has never been presented to any academic institution of higher learning for any academic award.

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APPROVAL

This research dissertation entitled "Determinants of Renewable Energy Consumption in Uganda" has been compiled by Mr. Ayoku Emmanuel under our guidance and is ready for submission for examination with our approval.

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ABSTRACT

Globally, renewable energy has gained significant attention as nations strive to increase its share in their energy mixes to mitigate environmental challenges and address the pressing issue of climate change. This study investigates the determinants of renewable energy consumption in Uganda, focusing on GDP per capita, carbon dioxide emissions, access to electricity, trade openness, and human development index. Utilizing a longitudinal research design with time series and quantitative approaches, we analyze data from the World Bank database covering 1990 to 2020. using the STATA statistical package. The analysis reveals both short-run and long-run relationships between Renewable energy consumption (Rec) and various factors, including GDP per capita (Gdp pc), Carbon dioxide emissions (Co2), Access to electricity (AE), Human Development Index (HDI), and Trade openness (TO). Using a Vector Error Correction Model (VECM) analysis, we find that:

In the short run, the error correction term is significant, indicating a short-run adjustment process towards long-run equilibrium. This suggests that renewable energy consumption (REC) is adjusting to its long-run equilibrium level. The lagged logarithm of Renewable energy consumption (REC) has a positive and significant coefficient, indicating a strong persistence in renewable energy consumption. This means that past renewable energy consumption (REC) patterns continue to influence current consumption. Human development index (HDI) has a negative but significant short-run effect on renewable energy consumption (REC), while the other factors have no significant effect.

However, in the long run, carbon emissions (Co2), GDP per capita (GDP pc), human development index (HDI), and trade openness (TO) have significant ($p<0.05$) long-run effects on renewable energy consumption. Notably, carbon dioxide emissions (Co2) and GDP per capita (GDP pc) have a significant positive effect on renewable energy consumption, while human development index (HDI) and trade openness (TO) have a significant but negative effect. Access to electricity (AE) becomes collinear with the error term and is thus omitted from the model.

LIST OF ABBREVIATIONS

CO2	Carbon dioxide
GDP pc	Gross Domestic Product per capita
TO	Trade Openness
HI	Human development Index
IRENA	International Renewable Energy Agency
REC	Renewable Energy Consumption
UBOS	Uganda Bureau of Statistics
WDI	World Development Indicators

CHAPTER ONE

1.0 Introduction

This chapter presents the background of the study, problem statement, purpose of the study, research objectives, research hypotheses, scope of the study, significance of the study, and the theoretical framework.

1.1 Background of the study

Renewable energy refers to energy produced from sources that do not deplete or sources that can be replenished in a person's lifetime (Ilechukwu, 2022).Renewable energy has gained an important share in the total energy consumption mix of many countries due to the environmental problems and climate change caused by dependence on the use of heavy fossil fuels(International Renewable Energy Agency (IRENA b),2018), it is recommended that renewable energy share in final energy consumption should at least be 90% and for non-renewable 36%. However, Projections for the short and medium-term do not forecast a reduction in consumption of fossil fuels in the world (Intergovernmental Panel on Climate Change, IPCC, 2007; International Energy Agency, IEA, 2006).Besides, the Tracking Sdg7 Energy Progress Report (2022) shows that global REC is only 17.7% of the total energy consumption in Uganda inclusive, despite the government's efforts in promoting sustainable energy development through the establishment of the Renewable Energy Policy (2007).

Renewable energy consumption is not a new concept in the energy consumption literature. Previous researchers have endeavored to examine the concept together with its determinants. Scholars that have examined the determinants obtain varying results and also use panel data for varying periods. For instance, Ergun et al. (2019) use data from 1990 to 2013 and find that countries with a higher Human Development Index and a higher gross domestic product per

capita have a lower share of renewable energy in the national grid but find that increase in foreign direct investment relates to higher renewable energy integration something contrary to previous findings such as those fop et al (2011) who find a robust but small effect of human capital development. Also, Pfeiffer and Mulder (2013) find a positive relationship between human capital development and renewable consumption unlike Ergun et al., (2019).Others examine the effect of democratic rights and find that in countries in which the democratic rights of people are preserved better, higher economic growth leads to increased use of renewable energy consumption while a negative association is found between economic growth and renewable energy consumption in less democratic countries(Chen et al., 2021). Whereas Ergun et al. (2019) find that foreign direct investment positively influences renewable energy consumption; Pfeiffer and Mulder (2013) find that foreign direct investment negatively influences renewable energy consumption. Also, Susana and Putri(2018) find a negative relationship between renewable energy consumption and carbon emissions; Liu et al., (2023) find that clean energy usage does not reduce carbon emissions while Raihan et al. (2023) find that an increase in carbon emissions may increase renewable energy consumption. Besides carbon emissions, Xu and Ullah (2023) found that GDP-per-capita influences renewable energy consumption while Somoye et al. (2023) find that GDP-per-capita has no relationship with renewable energy consumption. For access to electricity, scholars still have mixed arguments. While some scholars advance that access to electricity may enhance renewable energy consumption, other scholars argue that access does not guarantee the use of renewable energy sources(Makonese et al., 2018; Jan et al., 2012; Choumert-Nkolo et al., 2019).Others also advance that greater availability and consumption of renewable energy improve the rate of access to energy (Kouton, 2021).

Overall, different countries are at different levels thus causing a difference in the findings. Individual country characteristics and pathways are necessary given the significant differences.

Thus, this study aims to investigate the determinants of renewable energy consumption in Uganda, focusing on the role of carbon dioxide emissions, GDP per capita, access to electricity, trade openness, and human development index. By examining the relationships between these factors and renewable energy consumption, this study will provide valuable insights for policymakers and stakeholders to promote sustainable energy development in Uganda.

1.2 Problem Statement

Fische (2014) in his study of kick-starting the Implementation Phase of the Sustainable Energy for All (SE4All) Initiative in Uganda, under Uganda's Action Agenda (AA) and European Union Delegation to Uganda, recommended that renewable energy share in final energy consumption should at least be 90% and for non-renewable 36%. However, Projections for the short and medium-term do not forecast a reduction in consumption of fossil fuels in the world (Intergovernmental Panel on Climate Change, IPCC, 2007; International Energy Agency, IEA, 2006). The Government of Uganda through the Ministry of energy and mineral development has set ambitious targets to increase the share of renewable energy in its energy mix, but the country still faces significant challenges in transitioning to a sustainable energy system. While previous studies have explored the potential for renewable energy in Uganda, the empirical relationship between macroeconomic factors, environmental degradation, energy access, and renewable energy consumption remains poorly understood. This study therefore investigates the determinants of renewable energy consumption in Uganda, focusing on the role of:- Economic factors using GDP per capita, to examine the impact of economic growth on renewable energy consumption, Environmental factors using Carbon dioxide emissions, to assess the effect of

environmental degradation on renewable energy consumption, Energy access using Access to electricity, to evaluate the influence of energy access on renewable energy consumption and Trade factors using Trade openness, to examine the impact of international trade on renewable energy consumption and Human Development Index, to investigates the relationship between human development and renewable energy consumption.

1.3 Purpose of the Study

The purpose of this study was to establish the major determinants of renewable energy consumption in Uganda, focusing on the role of:

a) Economic factors: GDP per capita, to examine the impact of economic growth on renewable energy consumption and whether increasing prosperity drives demand for cleaner energy.
b) Environmental factors: Carbon dioxide emissions, to assess the effect of environmental degradation on renewable energy consumption and whether Uganda's efforts to reduce emissions are driving renewable energy adoption and consumption.
c) Energy access: Access to electricity, to evaluate the influence of energy access on renewable energy consumption and whether expanding energy access promotes or hinders renewable energy adoption.
d) Trade factors: Trade openness, to examine the impact of international trade on renewable energy consumption and whether trade policies and agreements facilitate or hinder the adoption of renewable energy technologies.
e) Human Development Index: to explore the relationship between human development and renewable energy consumption and whether improvements in living standards, education, and health lead to increased demand for renewable energy.

1.4 Specific Objectives of the Study

Specifically, the study seeks:

a) To assess the effect of GDP per capita on renewable energy consumption in Uganda.
b) To examine the effect of carbon dioxide emissions and renewable energy consumption in Uganda.
c) To assess the effect of access to electricity on renewable energy consumption in Uganda?
d) To examine the effect of Human Development Index on renewable energy consumption.
e) To ascertain the influence of trade openness on renewable energy consumption in Uganda

These specific objectives guided the study and ensured that it achieved its purpose. By examining these factors, the study provided valuable insights into the determinants of renewable energy consumption in Uganda and informs policymakers and stakeholders on effective strategies to promote sustainable energy development in Uganda.

1.5 Research Hypothesis

This study sought to test the following research hypotheses:

a) **Hypothesis 1**

H_1: There is no significant effect of GDP per capita on renewable energy consumption in Uganda.

b) **Hypothesis 2**

H_2: There is no significant effect of carbon dioxide emission on renewable energy consumption in Uganda.

c) **Hypothesis 3**

H_3: There is no significant effect of access to electricity on renewable energy consumption in Uganda.

d) **Hypothesis 4**

H_4: There is no significant effect of Human Development Index on renewable energy consumption in Uganda.

e) **Hypothesis 5**

H_5: There is no significant effect of Trade openness on renewable energy consumption in Uganda.

1.6 Scope of the Study

1.6.1 Content Scope

The research utilized an analysis of 5 factor variables: GDP per capita, carbon dioxide emissions, access to electricity, Trade openness and Human Development Index, the study aimed to investigate the relationship between the share of renewable energy consumption in Uganda in the period from 1990-2020. While doing so, the study controlled for the country's access to

electricity, carbon-emission levels in Kilo tones (Ktoe), Trade openness (Import and Exports) and human Development Index.

1.6.2 Geographical Scope

The research considered factors that determine Renewable Energy Consumption (REC) in Uganda.

1.6.3Time Scope

The research utilized a research design where data was collected at multiple points in time from the World Bank development Index and Uganda Bureau of Statistics UBOs. The data for this study covered a period of 30 years (1990-2020).

1.7 Significance of the Study.

a) The research findings will be used by policymakers to formulate policy instruments aimed at enhancing Renewable Energy Consumption as regards energy diversification in Uganda.

b) The research will contribute to knowledge by examining the determinants of renewable energy consumption in Uganda.

c) The research will make an academic contribution to renewable energy studies and climate change for scholars and researchers in the Energy Sector.

1.8 Theoretical framework of the Study.

The study is grounded on four theories that include the consumption theory, economic theory, theory of planned behavior, and the Social cognitive theory

In the context of renewable energy consumption, this means that consumers will adopt or make decisions on renewable energy sources if they are cost-effective and align with their economic

interests. Policies like tax incentives, subsidies, or feed-in tariffs can encourage renewable energy adoption and consumption.

The theory of planned behavior posits that consumers' energy consumption behavior is influenced by their attitudes, subjective norms, and perceived behavioral control. This includes attitudes towards renewable energy, such as perceived benefits and environmental concerns, as well as subjective norms like social pressure and community expectations. Perceived behavioral control, including access to resources and technology, also plays a role. Interventions like public awareness campaigns, education, and community engagement can shape attitudes and norms, increasing renewable energy adoption.

Social cognitive theory suggests that consumers' energy consumption behavior is shaped by personal factors, environmental factors, and behavioral factors. Personal factors include beliefs and attitudes, while environmental factors encompass social norms and access to resources. Behavioral factors, such as self-efficacy, also influence energy consumption behavior. Interventions like training programs, demonstrations, and social media campaigns can enhance self-efficacy and skills, promoting renewable energy adoption.

Overall, these theories provide a comprehensive framework for understanding the factors that influence renewable energy consumption behavior. By considering economic, social, and personal factors, policymakers and researchers can develop effective interventions to promote the adoption and consumption of renewable energy sources. Based on the factors mentioned above, a consumption function for renewable energy in Uganda could be developed as follows:

$$\mathbf{REC = f\ (GPP_{pc},\ CO2,\ AE,\ HDI,\ TO)}$$

Where:

REC = Renewable energy consumption

GDP_{pc} = GDP per capita (economic factor)

CO_2 = Carbon dioxide emissions (environmental factor)

AE = Access to electricity (energy access factor)

HDI= Human Development Index

TO = Trade openness (trade factor)

The function could be specified as:

$$\mathbf{REC = \beta 0 + \beta 1\ (GPP\ pc) + \beta 2\ (CO2) + \beta 3\ (AE) + \beta 4\ (HDI) + \beta 5\ (TO) + \varepsilon}$$

Where:

- $\beta 0$ is the intercept
- $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$, and $\beta 5$ are the coefficients of the respective variables
- ε is the error term.

This function suggests that renewable energy consumption is a function of economic growth, environmental degradation, energy access, human development, and trade openness. As these factors increase, renewable energy consumption also increases.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of studies on the parameters of GDP per capita, Carbon dioxide Emissions, and Technological Innovation selected in the study and their relationship with Renewable Energy Consumption.

2.1 GDP per capita and Renewable Energy Consumption.

According to Marques (2010), as regards to REC, one of the most frequently studied drivers is income or Gross Domestic Product (GDP). It is expected that as income per capita increases, REC will increase because increased income enables countries to manage the expenses of developing and using modern renewable energy technologies. Earlier research shows conflicting findings on the relationship between GDP per capita and REC. For instance, in some research, a positive relationship was found while other research shows contradicting results. Research where a positive relationship was obtained includes that of Sadorsky (2009) where Panel co integration estimates show that increases in real per capita income have a positive and statistically significant impact on per capita renewable energy consumption. InPfeiffer and Mulder (2013), their studies showed that real income, energy resource diversification and schooling level effect on renewable energy consumption, are statistically significant and positive whereas trade openness, foreign direct investment, policy support programs, electricity consumption growth and fossil fuel production all had negative effects. Nicholas et al. (2014) using the Panel co integration and error correction modelling reveals the presence of a long-run relationship between renewable energy consumption per capita and real GDP per capita among other variables and also long-run elasticity estimates show a positive and statistically significant effect

of real GDP per capita on renewable energy consumption thus showing that a feedback relationship exists among these variables.

Other studies obtaining similar findings include those by Lin and Moubarak(2014) where it is found that China's growing economy is conducive to the development of the renewable energy sector, offering promising contribution to further economic growth; Omri et al. (2015) who use static and dynamic panel data techniques find that per capita GDP among other variables like per capita CO2 emissions significantly drive renewable energy consumption; Neuhaus (2016) who find a long-run and statistically significant relationship between real GDP and renewable energy consumption and a unidirectional causal relationship running from GDP to renewable energy in Africa, especially in the long run; Kahia et al.(2017) who on using the generalized moment method (GMM) find renewable energy consumption in the long term positively affecting economic growth;Aneja et al. (2017) who find the presence of a long run relationship between economic growth and non-renewable energy as well as renewable energy consumption; Marinas et al.(2018) who used the ARDL method, both short and long term and found a significant relationship between the variables; Stamatios et al. (2018) find a positive relationship between economic growth and consumption of renewable energy in 25 EU member states from 2007 to 2016; Gozgor et al. (2020 find that per capita income positively impacts renewable energy among others; and lastlyFatima et al. (2021) who find that GDP moderates the relationship between RE and CO2 emissions while at the same time, GDP increases non-RE consumption which in turn also increases CO2 emissions.

Research having contradicting findings includes the works of Marques and Fuinhas (2011)that revealed that energy use per capita exerts a positive effect on renewable energy consumption, per capita CO2 emissions exert a negative effect on renewable energy consumption and per capita

GDP, energy imports, and fossil fuel prices exert no significant effect on renewable energy consumption; Menegaki (2011) who finds no causality between GDP and RWC; Ohlan (2016) reveals that non-renewable energy consumption has a long run significant positive impact on India's economic growth, and in the long-run elasticity results indicate a statistically insignificant relation between renewable energy consumption and economic growth in the 1971-2012 period;Attiaoui et al. (2017) who revealed that per capita GDP exerts no significant effect on renewable energy consumption;Fotourehchi (2017) who find a one-way causality between renewable energy consumption and economic growth; Khobai and Le Roux (2018) whose long-run results show a one-way causality relationship from renewable energy consumption to economic growth and short-run results show a one-way causality from economic growth to renewable energy consumption; Maji et al (2019) who find that renewable energy consumption reduces the rate of economic growth in these countries.Durgun and Durgun (2018) find no causal relationship between renewable energy and Economic growth; Nguyen and Kakinaka (2019) who find that in low-income countries, renewable energy consumption is positively related to GDPpc and negatively related in high-income countries; and lastly Chen et al. (2021) found a positive relationship between REC growth and GDP growth for only the developed countries in their dataset, while for the developing countries, the relationship is not statistically significant. The empirical evidence presented above suggests that the relationship between income per capita and REC is positive for relatively wealthier countries but negative for developing countries.

2.2 Carbondioxide Emission and Renewable Energy Consumption.

In recent years, energy consumption relying on burning fossil fuels has led to a rapid increase in global greenhouse gas emissions, causing climate change and environmental degradation (Ahmad et al. 2018; Hu et al. 2021; Zhang et al. 2021). Thus, this trend has resulted in various

studies in regard to the relationship between renewable energy consumption and Carbondioxide emissions.In this regard, a strand of literature found that renewable energy consumption decreases CO2 emissions across countries. First and foremost, “Renewable energy is almost carbon-neutral” (Ackah and Kizys, 2015: 1159; Akar, 2016). Findings of some studies showed that carbon emissions increase renewable energy consumption (Aguirre and Ibikunle, 2014; Apergis and Payne, 2014a, 2014b; Bengochea and Faet, 2012; Omri et al., 2015; Omri and Nguyen, 2014; Sadorsky, 2009b; Salim and Rafiq, 2012), however, some found the adverse effect of the emissions (Ackah and Kizys, 2015; da Silva et al., 2018; Marques and Fuinhas, 2011; Marques and Fuinhas, 2012) among others.

For instance, Sadorsky (2009) found that an increase in real GDP per capita in the long term and CO2 per capita are the main forces that support REC; Menyah and Wolde-Rufael (2010) found a unidirectional causality running from nuclear energy consumption to CO2 emissions without feedback but no causality running from renewable energy to CO2 emissions; Menegaki (2011) finds a causal link between CO2 and RWC was obtained. Menegaki (2011) revealed that an increase in RWC will reduce CO2; Salim’s (2014)empirical results show that non- renewable energy consumption increases CO2emissions, whereas renewable energy consumption decreasesCO2emissions; Qi et al. (2014) found that an increase in the level of CO2 and GDP leads to an increase in REC and High levels of carbon emissions will create a demand for a cleaner environment, and will encourage the use of alternative REC; Ackah & Kizys’s (2015) results show that per capita GDP and energy consumption have a significant positive effect upon REC and the effects of carbon emission and energy prices are negative and statistically insignificant; Saidi & Hammami’s (2015) shows that an increase in GDP and CO2 raises the renewable energy consumption; Akar’s (2016) finding shows that per capita CO2 emissions

among other variables exert no significant effect on renewable energy consumption; Dong et al. (2018) finds that Renewable energy decreases CO2 emissions both in short- and long-run and fossil fuel consumption leads to an increase in CO2 emissions; Chen et al. (2019) find that REC and trade has negative impact on emissions; Mendonca et al. (2020) find that GDP and population increase CO2 emissions, while RE decrease CO2 emissions; MB Jebli, Farhani, Guesmi (2020) find that except for the lower-middle income countries, renewable energy consumption leads to decrease CO_2 Emission; Shahnazi and Dehghan Shabani (2021) find that renewable energy reduces CO2; and Awosusi et al. (2022) find that globalization and renewable energy mitigates CO2 emissions.

2.3 Effect of Access to Electricity on Renewable Energy Consumption.

On-grid systems provide electricity through a connection to a local network that is linked to a transmission network (IEA 2017a). For most people around the world, electricity is provided by the electric grid, consisting of a large-scale integrated generation, transmission, and distribution network (REN21 2014). Power is generated in large, centralized power plants using coal, natural gas, nuclear power, hydropower, or solar energy as the energy source (IEA18 2017a). However, decentralized generation can also be connected to the transmission network at low voltage (e.g., solar photovoltaic (PV) units). In order to supply rural areas, an existing grid is often extended beyond urban and peri-urban areas (REN21 2017). Especially in remote, scarcely populated areas in developing countries, grid connection is hindered by high investment costs for power distribution infrastructure in conjunction with low power demand (Sauer, Rau &Kaltschmitt 2007).

Moner-Girona (2009) discussed the effect of rural electrification, where distributed renewable energy helps stimulate the local economy. Distributed grids based on renewable energy are

generally more competitive in rural areas with significant distances to the national grid and the low levels of rural electrification offer substantial openings for renewable energy-based mini-grid systems to provide them with electricity access (Edenhofer et al., 2011).

Because of the interaction of the electricity sector with several other aspects of the economy, the objective of maximizing electricity access is viewed in the context of the techno-economic feasibility of technology options, and in terms of other socio-political, environmental, and governance factors (Bhattacharyya, 2012b). The techno-economic aspects consider the reliability and sustainability of the technology options, operating capacity, financial viability, cost-effectiveness, attractiveness of the option to a potential investor, and the economic benefits of the option. The governance aspect considers whether the existing institutions in the country have the capacity to implement the proposed technology options; the socio-political aspect considers the acceptability of the proposed technology option, affordability issues as well as the development outcomes of the technology option such as local income generation, women empowerment, etc.; while the environmental aspect considers the adverse environmental effects of the technology option (Bhattacharyya, 2012b).

As a result, a strand of several scholars has carried out research to assess the implication of the above factors as follows. For instance, the World Energy Outlook report by the International Energy Agency (2018) estimates that about 600 million people lack access to electricity in Sub-Saharan Africa (SSA)despite the massive untapped potential of renewable energy resources that could be exploited for an affordable and secure supply of energy (Barasaet al., 2018).Gandini& de Almeida, (2017) focus on direct current micro grids based on solar power systems and storage optimization, as a tool for cost-effective rural electrification while Roxas and Santiago (2016) deliberated on how to effectively disseminate renewable energy in rural communities. Further,

Karim, Fahrin, Lipu, and Mahmud (2017) examine electricity access improvement using renewable energy and energy efficiency and focus on the urban poor area of Dhaka, Bangladesh while Palit& Sarangi, (2014, March) focus on renewable energy-based mini-grids for enhancing electricity access.

2.4 Human Development Index and Renewable Energy Consumption.

The relationship between renewable energy consumption and human development is a vital and increasingly important area of research, as the world transitions towards a more sustainable and equitable energy future. The debate surrounding the impact of energy on development has led to two distinct strands of research. One strand focuses on the contribution of renewable energy consumption to development, including its impact on economic growth, energy access, and human well-being. The other strand explores the energy transition theory, which examines the transformation of energy systems towards renewable energy sources and its implications for sustainable development. As renewable energy consumption continues to grow and play an increasingly important role in the global energy mix, understanding its relationship with human development is essential for informing policy and practice that supports a sustainable and equitable energy future. By examining the links between renewable energy consumption and human development, researchers and policymakers can better understand how to leverage renewable energy to promote sustainable development and improve human well-being.

Several studies have been on the relationship between renewable energy consumption: In terms of the economic literature, the work on the relationship between energy consumption and human development is moving in two directions. In the first direction, there is a controversy between, on the one hand, the orthodox view (Solow, 1956; Becker et al., 1990; Sen, 1999; Sinha & Sen, 2016; Menegaki, 2011), which does not acknowledge the contribution of energy to development

and thus to human development and, on the other hand, the heterodox review (Hansen &Percebois, 2010; Kané, 2009; Jumbe, 2004), according to which energy influences human development. In the second direction, we find the proponents of energy transition theory (Hosier & Dowd, 1987; Wang et al., 2020; Wang et al., 2018; Pirlogea, 2012). For the latter, the relationship between energy consumption and human development depends on the quantity and quality of energy. Therefore, the more developed a country is (high human development); the less it consumes fossil or unsuitable energy.

Pîrlogea, C. (2012) investigated the relationship between human development index (HDI) and renewable energy consumption, fossil fuel energy consumption, CO2 emissions intensity, and energy intensity for six European countries with high and very high HDI values between 1997 and 2008. The study found that fossil fuel consumption has a negative relationship with HDI for countries with high HDI values, while renewable energy consumption positively influences human development. Additionally, energy intensity variables contributed negatively to HDI, indicating that lower energy intensity levels are associated with better human development.

Kazar, G. and Kazar, A. (2014) examined the relationship between renewable electricity net generation and human development index (HDI) for 154 countries, divided into five panels based on HDI levels. The study covered two periods: 1980-2010 for long-term effects and 2005-2010 for short-term effects. The findings exhibited a unidirectional Granger causality from renewable electricity net generation to HDI in both the short and long run. These studies suggest that renewable energy consumption is positively related to human development, while fossil fuel consumption and energy intensity have negative relationships with HDI. The findings also indicate that the relationship between renewable energy consumption and HDI is influenced by

the level of human development, with countries having higher HDI values exhibiting a stronger positive relationship.

One study by Wang et al. (2018) investigated the association between renewable energy usage, economic growth, and HDI in Pakistan from 1990 to 2014 using the 2SLS technique. However, the empirical findings suggested that renewable energy does not contribute to the human development process in Pakistan. In contrast, Salam et al. (2020) found a strong interrelationship between energy use and HDI in South Asia economies, suggesting that sufficient energy resources are essential for mounting economic and human development. This implies that renewable energy could play a crucial role in promoting human development in these regions. However, Amer (2020) found that renewable energy has a negligible impact on HDI in high-income group countries, suggesting that the relationship between renewable energy and HDI may vary depending on the economic context. Further research is needed to explore this relationship and its implications for sustainable development.

A study by Wang et al. (2018) investigated the association between renewable energy usage, economic growth, and HDI in Pakistan from 1990 to 2014, employing the 2SLS technique. However, the findings surprisingly suggested that renewable energy does not contribute to the human development process in Pakistan. In contrast, Salam et al. (2020) discovered a strong interrelationship between energy use and HDI in South Asia economies, highlighting the essential role of sufficient energy resources in driving economic and human development. This implies that renewable energy could be a vital component in promoting human development in these regions. However, Amer (2020) found that renewable energy has a negligible impact on HDI in high-income group countries, suggesting that the relationship between renewable energy and HDI may vary depending on the economic context.

Further research is necessary to explore this relationship and its implications for sustainable development, particularly in different economic settings. By investigating the link between renewable energy and HDI, policymakers and researchers can better understand how to leverage renewable energy to promote human development and sustainable growth.

2.5 Trade Openness and Renewable Energy Consumption.

Trade openness entails the movement of goods produced in one country for consumption or further processing in another country. The production of these goods requires effective energy use. Several studies have concluded that trade openness by nations influences domestic energy use in various ways. Empirical studies have shown that trade openness may have a significant impact on renewable energy consumption (Omri& Nguyen, 2014; Akar, 2016; Amri, 2019; Alam & Murad, 2020; Murshed, 2020; Zeren &Akkus, 2020).

Most studies on the impact of trade openness on renewable energy consumption are based on the theoretical framework proposed by Grossman and Krueger (1991). They proposed that trade openness affects energy consumption through scale, composition, and technology effects. Additionally, Shahbaz et al. (2014) and Wan et al. (2015) argued that economic growth influences domestic energy use through trade openness, economies of scale, technological effects, and production factors.

However, most studies have only applied the linear hypothesis (Omri& Nguyen, 2014; Akar, 2016; Rasoulinezhad & Saboori, 2018; Amri, 2019; Alam & Murad, 2020; Lee et al., 2021). The linear hypothesis implies that scale, composition, and technology effects remain unchanged or follow consistent changes with trade openness. Nevertheless, these effects may follow inconsistent and uncoordinated changes with changing trade openness, leading to a nonlinear relationship between trade openness and renewable energy consumption.

To address this, Bellakhal et al. (2019) and Qamruzzaman& Wei (2020) provided evidence for the nonlinear impact of trade openness on renewable energy consumption. Sadorsky (2011) also found that trade volumes increase domestic energy use. Moreover, Semancikove (2016) revealed that trade openness benefits sustainable development by efficiently utilizing resources and improving economies of scale. Trade also plays a vital role in technology transfer for renewable energy (Khan et al., 2017).

Studies have empirically established the long-run association between renewable energy use and trade in different countries (Chowdhury et al., 2014; Jebli et al., 2014; Solarin, 2014). Aïssa et al. (2014) used panel cointegration to examine the relationship between renewable energy consumption, trade, and output in 11 African countries from 1980 to 2008. The results show bidirectional causality between output and exports/imports in both the short and long run.

However, there is no causality between trade and renewable energy consumption in the short run, and no long-run causality from trade to renewable energy. Most studies have used imports, exports, and total trade as proxy variables for trade openness, which represent different trade characteristics. A comparative analysis of these variables may yield more accurate results.

The traditional energy trade model should be improved by adding essential variables to correct errors and improve accuracy. The relationship between trade openness and energy consumption is crucial, as energy plays a key role in exports and imports. Policies aiming to reduce energy consumption may negatively impact trade openness and vice versa.

In conclusion, trade openness significantly enhances the flow of technology, investment, and knowledge, driving renewable energy consumption by: Importing advanced technologies, transferring technology through trade agreements, attracting foreign direct investment; it provides access to international financing mechanisms, invests in infrastructure development,

and facilitates public-private partnerships. Additionally, trade openness fosters international cooperation, collaboration on research and development, and capacity building in renewable energy.

However, the relationship between trade openness and renewable energy consumption is complex and influenced by various factors such as economic growth, technology transfer, and energy efficiency. Policies aiming to reduce energy consumption and promote renewable energy should consider the impact of trade openness on renewable energy consumption and aim to create a favorable environment for trade and investment in renewable energy technologies. By leveraging these benefits, trade openness can play a vital role in driving renewable energy consumption and mitigating climate change.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter presents the methodology that was used in the study; it includes the study area, data collection methods, data collection tools, data management, and analysis.

3.1 Research Design

The study was longitudinal. Time series and quantitative methods of analysis were used. According to Wang et al., (2017), longitudinal research estimates are more accurate parameters, and allow researchers to begin answering four types of questions: (a) causal priority, (b) future prediction, (c) change, and (d) temporal external validity and desirable for longer time lag observations.

3.2Description of Data Types and Data Sources

3.2.1 Data Types

The study used annual secondary data that covers the period 1990-2020. The variables of interest were renewable energy consumption; GDP per capita, CO2 emissions, access to electricity, Trade Openness and Human development Index.

3.2.2 Data Sources

All data for study variables was sourced from the World Bank's Development indicators Database.

3.2.3 Description of Study Variables

Dependent Variable

Renewable Energy consumption was the dependent variable which was assessed based on how it is influenced by the different identified explanatory variables. Renewable energy consumption was measured as a percentage share of renewable energy in the total final energy consumption.

Independent Variables

The following are the independent variables; GDP per-capita, carbon dioxide emission, access to electricity, Trade Openness and Human Development Index:

Gross Domestic Product (GDP) per capita is a core indicator of economic performance and is commonly used as a broad measure of average living standards or economic wellbeing, despite some recognized shortcomings. For example, average GDP per capita gives no indication of how GDP is distributed between citizens. Average GDP per capita may rise for example but more people may be worse off if income inequalities also increase.

Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Carbon dioxide emissions, largely by-products of energy production and use, account for the largest share of greenhouse gases, which are associated with global warming. Carbon dioxide emissions were measured in units called kilotonnes (kt).

Access to electricity is the percentage of population with access to electricity. Electrification data was collected from industry, national surveys and international sources. Access to electricity was measured as percentage (%) of population.

Trade Openness was calculated as ((Exports + Imports)/GPD*100).

Human Development Index values that are comparable across years were obtained from the interpolated data at http://hdr.undp.org/en/data, which present trends using consistent data.

3.3 Econometric Model

The dependent variable (Yi) was the Renewable Energy consumption (REC) which was obtained using derived formula:

$$\mathbf{Yi = f(X1, X2, X3, X4, , X5 \ldots ei)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbf{(2)}$$

Where:

Y_i - Renewable Energy Consumption (REC),

X_1 –Gross Domestic Product per carpita (GDPpc),

X_2–Carbon dioxide emission (CO_2,

X_3 – Access to Electricity (AE)

X_4 -Human Development Index,

X_5 –Trade Openness and

e_i– error term.

So, $\mathbf{Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X5 + e_i}$ .... **(3)**

According to (Hanck et al., 2019), we assumed the true relationship between Y and X_1 , X_2, X_3, X_4 and X_5 to be linear and on average this relation was given by the population regression function:

$$\mathbf{E\ (Yi\ |X1i = x_1, X2i = x_2, \ldots X5i = x_5.) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5} \ldots\ldots\ldots \mathbf{(4)}$$

But this relationship did not hold exactly since there was disturbing influences to the dependent variable Y which we could not observe as explanatory variables. Therefore, an error term e_i which represents deviations of the observations from the population regression line was added to get:

$$\mathbf{Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e_i} \text{ ..... (5)}$$

And this yielded the population multiple regression models. However, since the different exogenous variables were not measured in the same units, then the model was finally transformed for consistent analysis and minimizing errors by introducing logarithmic multiplier.

Hence the specified model was:

$$\mathbf{Y_i = \beta_0 + \beta_1 InX_1 + \beta_2 InX_2 + \beta_3 InX_3 + \beta_4 InX_4 + \beta_5 InX_5 + e_i} \text{ ..... (6)}$$

3.4 Data Analysis

The data was processed and analyzed using the STATA statistical package.

3.4.1 Descriptive Statistics

First, the data was cleaned by checking for missing values and outliers. Descriptive statistics were summarized to provide a general description of the data characteristics. This was done to ensure that the data had a normal distribution otherwise it would produce misleading results. In particular, a summary of the mean, minimum, maximum variance and standard deviation values was computed.

3.4.2 Diagnostic Tests

Unit Root Test for Stationarity

To test for Stationarity, the Augmented Dickey Fuller (ADF) test was used.

TABLE 3.4.2 1.SHOWING THE STATIONARITY TEST RESULTS FOR THE LEVEL AND DIFFERENCED VARIABLES.

Level Variable			*After differencing to order one*		
Variable	*p-value*	*Comment*	*Variable*	*p-value*	*Comment*
Ae	0.9963	Non stationary	access	0.0000	Stationary
Co2	1.0000	Non stationary	dco2	0.0000	Stationary
Gdp	0.9983	Non stationary	dgdp	0.0000	Stationary
Rec	0.9890	Non stationary	drec	0.0000	Stationary
Hdi	0.0000	Stationary			
TradOpen	0.8120	Non stationary	dTop	0.0000	Stationary

Source: *Analyzed Research Data.*

The level variables were found to be nonstationary because their p-values were all greater than 0.05 while their order one (1) were found stationary because all their p-values are less than 0.05 which implies that the unit root is absent in the differenced variables to order 1 unlike for the level variables which have unit roots in each variable.

Linearity test

The Analysis of Variance (ANOVA) for regression was used to establish the possibility of the linearity between the dependent variable and independent variables

TABLE 3.4.2 2: SHOWING THE LINEARITY TEST RESULTS

Source	SS	df MS	Number of obs	124
			F (5, 118)	472.17
Model	0.053039	5 .010607838	Prob > F	0.0000
Residual	0.002651	118 .000022466	R-squared	0.9524
			Adj R-squared	0.9504
Total	0.05569	123 .000452766	Root MSE	0.00474

Source: *Analyzed Research Data*.

Firstly, the R-squared and adjusted R-squared values of the regression are above 0.5 that is, 0.9524 and 0.9504 respectively, which imply a good fit as about 95% of the changes in the dependent variable are explained by the independent variables. Secondly, the P-value of the F

statistic is significant (F=427.17, p<0.05) is less than 0.05 which implies the presence of the linear relationship between the dependent and independent variables.

Normality Test

The study used the skewness/kurtosis test to test for normality of the residuals or error terms.

TABLE 3.4.2 3: SHOWING THE NORMALITY TEST RESULTS

Variable	*Obs*	*Pr (Skewness)*	*Pr (Kurtosis)*	*adj chi2(2)*	*Prob>chi2*
myResid	124	0.0301	0.0004	14.21	0.0008

Source: *Analyzed Research Data*

Since the P-value of 0.0008 is less than 0.05, the null hypothesis that the residuals are normally distributed is rejected, thus the residuals of the regression are not normally distributed. This test also agrees with the Shapiro-Wilk W test for normal data with p-value of 0.00004 which is less than 0.05 which implies that the errors are not normally distributed. The remedy for non-normality of the error term is transforming the variables using the natural logs which were done and the error became normally distributed.

Multicollinearity Test

The study used Variance Inflation Factor (VIF) to test for Multicollinearity among the independent variables.

TABLE 3.4.2 4: SHOWING THE MULTICOLLINEARITY TEST RESULTS

Variable	*VIF*	*1/VIF*
LnCo2	55.1	0.018149
LnGdp	28.5	0.035086
LnHDI	17.03	0.058729
LnTO	5.04	0.198337
LnAE	4.71	0.21246
Mean VIF	22.08	

Source: *Analyzed Research Data*

The VIF value of 22.08 is higher the recommended value, 5 which implies presence of Multicollinearity among the predictor variables which calls for correcting for Multicollinearity. Since the predictor variables are correlated, this made it hard for the researcher to use the ordinary least squares regression model to avoid obtaining spurious results and cannot be used for forecasting, thus need for an alternative model that is less affected by Multicollinearity or simply correcting for Multicollinearity.

Heteroscedasticity Test

The study used the Cameron and Trivedi's decomposition of IM-test test for Heteroscedasticity.

TABLE 3.4.2 5: SHOWING THE HETEROSCEDASTICITY TEST RESULTS

Source	*chi2*	*df*	*P*
Heteroscedasticity	71.07	20	0.0000
Skewness	20.46	5	0.2283
Kurtosis	1.66	1	0.1918
Total	93.18	26	0.0000

Source: *Analyzed Research Data***.**

The overall p-value of 0.0000 which is less than 0.05 implies that there is significant Heteroscedasticity because the null hypothesis of constant variance for the error term was rejected. This implies that the ordinary regression would produce spurious results.

Autocorrelation Test Results

For autocorrelation, the Durbin-Watson test was used and the Durbin-Watson d-statistic of (6, 124) = 0 .0184044 was obtained which is less than 2 implying that there is significant positive autocorrelation between the error terms and predictor variables. This implies that the ordinary least squares regression model would produce spurious results.

3.5 Determining the Lag Length for Johannsen Test

The study used the Akaike information criterion, Hannan-Quinn information criterion, and Schwarz's Bayesian Information Criteria and compared the results.

The values with an asterisk (*) show the optimum number of lags to use in the cointegration test as established by criteria above of which they all agree on the optimum number of lags being 2 and that is what was used in the cointegration test.

TABLE 3.5 1: SHOWING THE MAXIMUM LAG LENGTH FOR THE JOHANNSEN COINTEGRATION TESTS

lag	*LL*	*LR*	*df*	*P*	*FPE*	***AIC***	*HQIC*	*SBIC*
0	656.691				7.90E-13	-10.8449	-10.7883	-10.7055
1	2086.1	2858.8	36	0.000	6.50E-23	-34.0683	-33.6721	-33.0927
2*	2260.4	348.61*	36	0.000	6.5E-24*	-36.3734*	-35.6376*	-34.5615*
3	2283.81	46.813	36	0.107	8.10E-24	-36.1635	-35.0881	-33.5154
4	2302.74	37.869	36	0.384	1.10E-23	-35.8791	-34.4641	-32.3947

Source: *Analyzed Research Data***.**

6.5.1 Cointegration Test

The Johannsen test was used for cointegration which very is appropriate for this test. The null hypothesis is rejected if the trace statistic is greater than the 5% critical value.

TABLE 3.5 2: SHOWING THE RESULTS OF THE JOHANNSEN TEST

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	42	2215.008	.	175.4257	94.15
1	53	2256.102	0.49017	93.2375	68.52
2	62	2276.187	0.28055	53.0674	47.21
3	69	2288.536	0.18326	28.3700*	29.68
4	74	2295.105	0.10209	15.2319	15.41
5	77	2300.034	0.07762	5.3748	3.76
6	78	2302.721	0.0431		

Source: *Analyzed Research Data***.**

From the results in table 3.5.2, the hypothesis that there are 3 co integrating equations could not be rejected. Nonetheless, the Johansen test establishes the rejection point using the asterisk (*) which is observed at maximum rank 3. At this rank, the null hypothesis that there are three (3) co integrating equations cannot be rejected since its trace value is less than it's the 5% critical value.

Conclusion

The diagnostic results have established that there are significant autocorrelation effects, Heteroscedasticity, Multicollinearity problems and non-Stationarity of the level variables, which make ordinary least squares regression not efficient because it produces spurious results which cannot be used for forecasting thus need for alternative model which is least affected by these effects to explain the relationships. Furthermore, the results showed that there are three co integrating equations in the series using the Johansen test for cointegration thus presence of both short run and long run equilibrium relationship effects of the independent variables on the dependent variable.

Therefore, the researcher used the Vector Error Correction Model (VECM) which is also known as the restricted VAR model and it is appropriate when the level variables are non-stationary but become stationary when differenced to order one (1) only and if cointegration exists. More so, this VECM model has strong predicting power with greater precision and established the short run and long run equilibrium relationship unlike the Ordinary Least Squares method.

3.6. VECM Model Specification for the Lead Variable

$$\Delta lnrec_t = \alpha + \sum_{i=1}^{k} \beta_i \, \Delta lnrec_{t-i} + \sum_{j=1}^{k} \gamma_j \, \Delta lngdp_{j-i} + \sum_{m=1}^{k} \varphi_m \, \Delta lnCo2_{m-i} + \sum_{n=1}^{k} \rho_n \, \Delta lnae_{n-i} + \sum_{r=1}^{k} \infty_r \, \Delta lnhdi_{r-i} + \sum_{s=1}^{k} \emptyset_s \, \Delta lnTop_{s-i} + \lambda_1 ECT_{t-1} + u_{it} \quad \ldots\ldots (7)$$

However, taking the first lags of the variables, the VEM model can be simplified to;

$$\Delta lnrec_t = \alpha + \beta \Delta lnrec_{t-1} + \gamma \Delta lngdp_{t-1} + \varphi \Delta lnco2_{t-1} + \rho \Delta lnae_{t-1} + \infty \Delta lnhdi_{t-1} + \emptyset \Delta lnTop_{t-1} + \lambda_1 ECT_{t-1} + u_{it} \quad \ldots\ldots (8)$$

3.6.1. The Long run Error Correction Model

$$ECT_{t-1} = \alpha + \beta \Delta lnrec_{t-1} - \gamma \Delta lngdp_{t-1} - \varphi \Delta lnco2_{t-1} - \rho \Delta lnae_{t-1} - \infty \Delta lnhdi_{t-1} - \emptyset \Delta lnTop_{t-1} \quad \ldots\ldots (9)$$

This model determines the long run equilibrium relationship between the dependent variable and the independent variables.

3.7 Ethical Considerations

The study was conducted in a way that all information provided by the various bodies was handled with a high level of confidentiality. Results from this study were shared among the various stakeholders to enhance its contribution towards policy formulation and management.

CHAPTER FOUR

PRESENTATION AND INTERPRETATIONOF FINDINGS

4.0. Introduction

This chapter presents the findings of the study, and their interpretation with respect to the study objectives.

4.1. Descriptive analysis results for the variables

The mean, standard deviation, minimum and maximum values of the study variables were obtained.

TABLE 4.1 1: SHOWING THE DESCRIPTIVE ANALYSIS RESULTS

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Rec	125	93.88626	1.810177	90.07	96.84246
Gdp	125	1.65	1.24	2.86	4.05
Ae	125	14.64979	12.17845	0.533899	45.22035
co2	125	2504.155	1542.305	730	5860
Hdi	124	0.437613	0.081175	0.289031	0.54525
Trade_openness	124	0.329518	0.052211	0.264784	0.437408

Source: *Analyzed Research Data*.

From the descriptive results, it was observed that an average of 2504.155 kt of carbon dioxide emissions was released from burning of fuels and manufacture of cement on a quarterly basis while on the same time basis, the average renewable energy consumed is 93.88% of the total final energy consumed in Uganda as the maximum percentage ever is 96.84% and minimum 90.07% which values show that Ugandans still rely more on renewable energies as compared to the non-renewable energy sources. More so, 14.65% of Ugandans have access to electricity on a quarterly basis but most importantly, the maximum access rate is 45.22% which is the most current rate as per data. Lastly, quarterly average GDP per capita of Uganda is 1.65 US Dollars.

4.2 Correlation between the Study Variables

This was used to establish the nature of relationships between the study variables.

TABLE 4.2 1 SHOWING THE CORRELATION RESULTS

	Rec	ae	co2_em	gdp	hdi	Trade-Open
rec	1					
ae	-0.9018*	1				
co2_emissi~_	-0.9650*	0.9407*	1			
gdp__curre~_	-0.9280*	0.8405*	0.9603*	1		
hdi	-0.9046*	0.8028*	0.9147*	0.9027*	1	
Trade-Open	-0.7374*	0.6395*	0.7972*	0.8546*	0.8165*	1

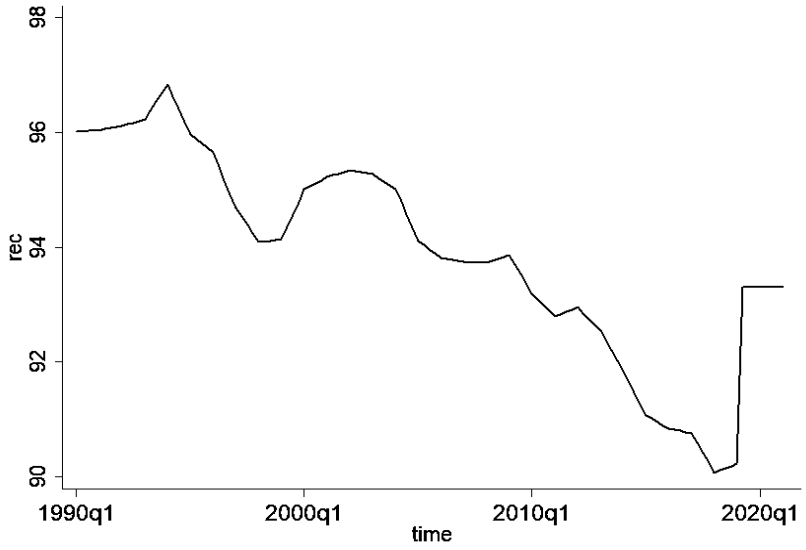
Source: *Analyzed Research Data*

From the Table 4.2.1, the correlation matrix results show that there was a very strong negative relationship between Renewable energy consumption (REC) and each of the five predictor variables of GDP per capita, carbon dioxide emissions (Co2), human development index (HDI), Trade openness (TO) and access to electricity (AE). The negative relationship implies that as one variable is increasing, the other variable is decreasing. However, it's important to note that correlation does not imply causation, and further analysis is needed to understand the underlying relationships between these variables.

4.3 Line Graphs showing the Trends of the Study Variables

These line graphs show how the study variables changed with time from 1990 up to 2020 showing the trends and other nonlinear variations.

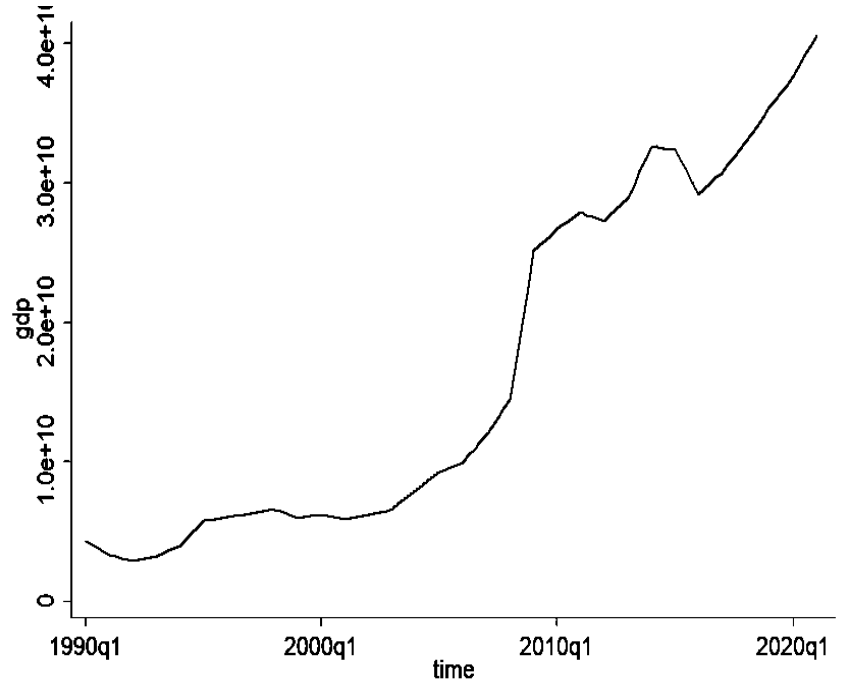
A line graph showing the growth trend in renewable energy consumption from 1990 to 2020 in Uganda.



Source: *Analyzed Research Data*

The line graph for renewable energy consumption showed that the percentage of renewable energy consumed has been reducing drastically since 1990 to around 2019 and then it started to increase sharply. This decreasing behavior affects the relationship between renewable energy consumption and any other predictor variable with a positive trend.

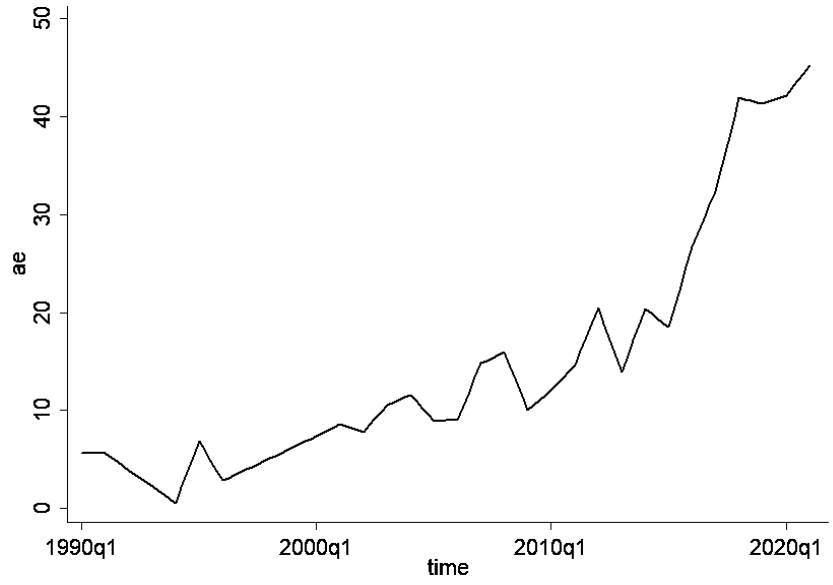
A line graph showing the growth trend in GDP per capita in Uganda from 1990 to 2020



Source: *Analyzed Research Data***.**

The GDP per capita against Time line graph shows that GDP per capita of Uganda has been rising with a generally increasing trend. However, the growth is not smooth. For example, a slow growth is observed between 1990 and around 2009. An increasing growth rate is observed between 2009 and around 2017 though with some booms and troughs. A sharp growth was observed after 2017.

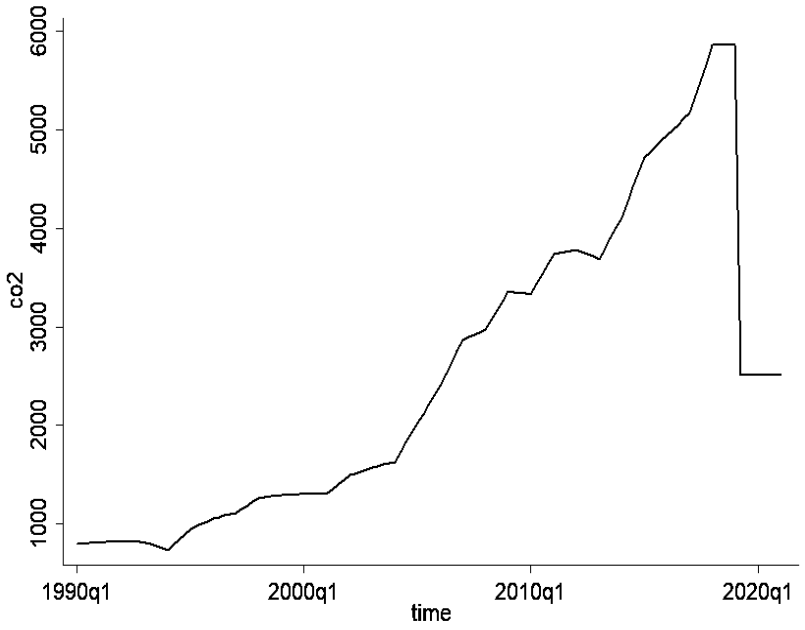
A line graph showing the growth pattern of access to electricity in Uganda from 1990 to 2020



Source: *Analyzed Research Data***.**

The Electricity Access against Time line graph shows that the percentage of people gaining access to electricity in Uganda has been rising though the trend is not smooth. An exceptional increase was observed between 2015 and to about 2018 where there was a sharp increase in the access rate which can be attributed to the vigorous efforts to increase access to electricity through rural electrification and increasing electricity generation.

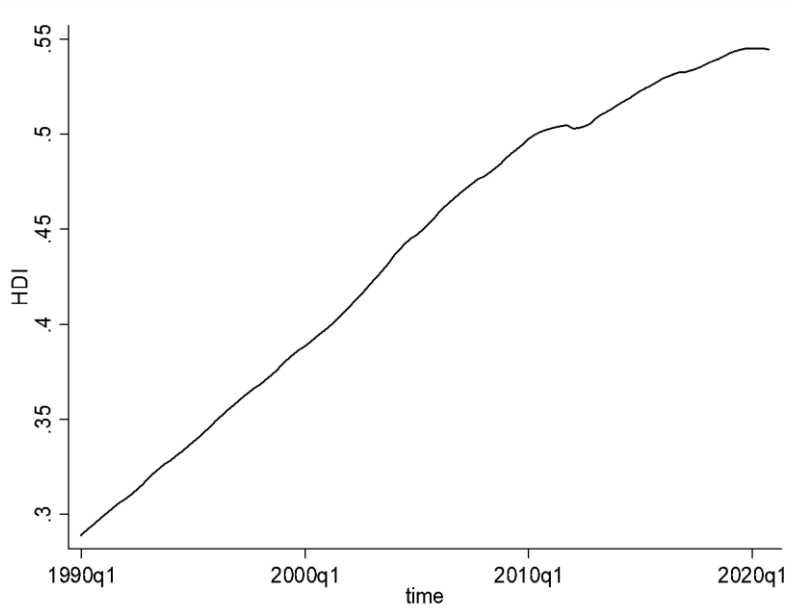
A line graph showing the growth pattern of carbon dioxide emissions in Uganda from 1990 to 2020



Source: *Analyzed Research Data***.**

From the graph of carbon dioxide against Time, it is observed that the carbon dioxide released to the environment has been on the rise since 1990 as per the data set. A slow rate is observed between 1990 and around 2005. After 2005, a slightly higher rate of carbon dioxide emissions was observed until around 2017. However, after this period, the amount of carbon dioxide emissions decreased drastically. This can be attributed to the world's call on climate change where carbon dioxide emissions are a huge contributor to this effect.

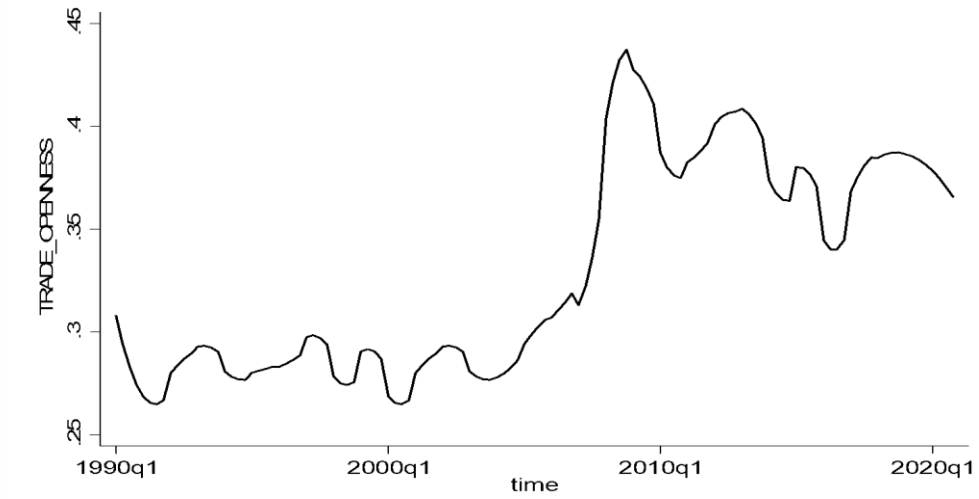
A line graph showing the growth trend in Human development Index from 1990 to 2020 in Uganda



Source: *Analyzed Research Data***.**

From the graph of Human Development Index against Time, it is observed that the welfare of the people measured as human development has been on the rise since 1990 at a high rate as slope of the curve. This can be attributed to the constant efforts by government it provides health care, education, water and sanitation, food and other basic human needs.

A line graph showing the growth trend in Trade Openness from 1990 to 2020 in Uganda.



Source: *Analyzed Research Data***.**

However, from the graph of trade openness against time, it is observed that Uganda's engagement in global trade was low between 1990 and 2005 which however improved greatly after then until 2010 and again dropped slightly in the next years until 2020 which can be attributed to the competition at the global market. World's call on climate change where carbon dioxide emissions are a huge contributor to this effect.

4.4. Significance of the Vector Error Correction Model

All p-values of the equations are less than 0.05 which shows that all equations are significant at 5% level of significance. Additionally, all their R-squared vales are greater than 0.5 apart from that of trade openness which is 0.3 but still good enough for prediction which show that the predictors explain the changes in the response variable.

TABLE 4.4.1 SHOWS THE SIGNIFICANCE OF THE VECTOR ERROR CORRECTION MODEL SHORT-RUN EQUATIONS FOR EACH VARIABLE

Equation	Parms	RMSE	R-sq.	chi2	P>chi2
D_LnRec	8	0.001115	0.5236	125.3129	0.0000
D_LnAE	8	0.219789	0.6235	188.8232	0.0000
D_LnCo2	8	0.021554	0.573	152.9629	0.0000
D_LnGdp	8	0.029993	0.6375	200.4566	0.0000
D_LnHDI	8	0.00112	0.9647	3118.333	0.0000
D_LnTO	8	0.021383	0.301	49.07922	0.0000

Source: *Analyzed Research Data***.**

4.4.1. Short run relationship co-efficient

TABLE 4.4.2 SHOWING THE SHORT RUN VECM EQUATION FOR RENEWABLE ENERGY CONSUMPTION

Variable	*Coeff.*	*Stand.Err.*	*z*	*P>z*	*(95% Conf.*	*Interval)*
_ce1. L1	-0.01675	0.007555	-2.22	0.027	-0.0315548	-0.00194
LnRec LD.	0.571388	0.087665	6.52	0.000	0.3995677	0.743208
LnAE. LD	-0.00032	0.00036	-0.9	0.37	-0.0010276	0.000383
LnCo2 LD.	0.007141	0.005349	1.34	0.182	-0.003342	0.017625
LnGdp LD.	-0.00417	0.002631	-1.58	0.113	-0.0093244	0.000987
LnHDI LD.	-0.16307	0.06384	-2.55	0.011	-0.2881974	-0.03795
LnTO LD.	-0.00541	0.005011	-1.08	0.281	-0.0152278	0.004414
_cons	-0.00052	0.000252	-2.07	0.038	-0.0010143	-2.8E-05

Source: *Analyzed Research Data***.**

Firstly, the error correction term (_ce1.L1) is significant, indicating a short-run adjustment process towards long-run equilibrium. This suggests that renewable energy consumption is adjusting to its long-run equilibrium level.

Additionally, the lagged logarithm of renewable energy consumption (LnRec LD) has a positive and significant coefficient, indicating a strong persistence in renewable energy consumption. This means that past renewable energy consumption patterns continue to influence current consumption whereas Human development index has a negative but significant short run effects ($p<0.05$) on renewable energy consumption while the rest have no significant effect ($p>0.05$).

Overall, these findings provide insights into the short-run dynamics of renewable energy consumption and its relationships with various macroeconomic and environmental variables.

4.4.2. The long run equilibrium Error correction (VECM) model

From equation (9), the long run equilibrium Error correction model, the signs of the coefficients are reversed during interpretation. The results in 4.4.3 show that carbon emissions, GDP, human development index and trade openness have significant ($p<0.05$) long run effects on renewable energy consumption.

TABLE 4.4.3 SHOWING THE LONG RUN ERROR CORRECTION MODEL FOR RENEWABLE ENERGY CONSUMPTION

	beta	Coef.	Std. Err	z	P>z	[95%	Conf. Interval
_ce1	LnRec	1	.	.	.	.	.
	LnAE	0	(omitted)				
	LnCo2	0.048077	0.02068	2.32	0.020	0.007546	0.0886077
	LnGdp	0.09447	0.016359	5.77	0.000	0.062406	0.1265335
	LnHDI	-0.24241	0.053905	-4.5	0.000	-0.34806	-0.1367554
	LnTO	-0.2172	0.038071	-5.71	0.000	-0.29182	-0.1425824
	_cons	-7.58944	.	.	.	.	.

Source: *Analyzed Research Data*.

Notably, carbon dioxide emissions and GDP have a significant positive effect on renewable energy consumption while human development index and trade openness have significant Negative effects on renewable energy consumption. However, in the long run, access to electricity becomes collinear with the error term and thus omitted from the model.

$$ECT_{t-1} = -7.59 + \Delta lnrec_{t-1} + 0.09\Delta lngdp_{t-1} + 0.05\Delta lnco2_{t-1} - 0.24 lnhdi_{t-1} - 0.22\Delta lnTop_{t-1} \ldots \ldots (10)$$

4.5 Post VECM Diagnostics

In order to check the goodness of fit of the Error Correction Model specified, the following post-VECM diagnostics tests were performed and conclusions were made accordingly; including granger causality, normality, autocorrelation, and model stability tests.

Granger Causality Results

The Wald's test for granger causality was used to estimate causality between the predictors and dependent variable and it was established that only human development index has a causality effect ($p<0.05$) on renewable energy consumption while the rest of GDP, carbon dioxide emissions, trade openness and access to electricity have no causality have no causality effect on renewable energy consumption ($p>0.05$).

TABLE 4.4.4SHOWING THE GRANGER CAUSALITY TEST RESULTS

equation	*causality direction*	*chi2*	*prob>chi2*
1	From electricity access to REC	0.8	0.3703
2	From caron emission to REC	1.78	0.1818
3	From GDP to REC	2.51	0.113
4	From HDI to REC	6.52	0.0106
5	From Trade Openness to REC	1.16	0.2805

Source: *Analyzed Research Data.*

Autocorrelation Test

The p-values of the autocorrelation results are all greater than 0.05 which implies that the null hypothesis that there is no autocorrelation cannot be rejected. Therefore, it implies that there is no autocorrelation in the residuals of the error correction model making VECM model significant and accurate to make predictions.

TABLE 4.4.5 SHOWING THE AUTOCORRELATION TEST RESULTS

lag	chi2	df	Prob > chi2
1	39.4458	36	0.31851
2	29.1915	36	0.78214

Source: *Analyzed Research Data.*

Normality of the Error Terms

Using the Jarque-Bera test, all the P-values are less than 0.05 implying that the null hypothesis of normality can be rejected at 5% level of Significance. Therefore, the error terms of the VECM model are not normally distributed. However, normality is not a necessary condition for the validity of the statistical procedures related to VECM models (Lutkepohl, 2009).

TABLE 4.4.6 SHOWING THE NORMALITY TEST RESULTS FOR THE VECM MODEL

Equation	*chi2*	*df*	*Prob>chi2*
D_LnRec	56.367	2	0.0000
D_LnAE	731.453	2	0.0000
D_LnCo2	73.593	2	0.0000
D_LnGdp	119.48	2	0.0000
D_LnHDI	19.022	2	0.00007
D_LnTO	85.372	2	0.00000
ALL	1085.287	12	0.0000

Source: *Analyzed Research Data***.**

Stability of the VECM Model

The Error Correction model produced five-unit moduli which are above the minimum 2 required moduli. Therefore, the model satisfies the stability condition hence the coefficients are reliable.

TABLE 4.4.7 SHOWING THE STABILITY OF THE VECM MODEL

Eigen value			Modulus
1			1
1			1
1			1
1			1
0.95543			0.95543
0.615803	+	.5584238i	0.831294
0.615803	-	.5584238i	0.831294
0.734866	+	.142481i	0.748552
0.734866	-	.142481i	0.748552
0.513225	+	.2332248i	0.563731
0.513225	-	.2332248i	0.563731
0.534962			0.534962

Source: *Analyzed Research Data***.**

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

4.5. Discussion of Results

This section discusses the results of the study as per objective as stated in the introduction.

Objective one: Assessing the effect of GDP per capita on renewable energy consumption in Uganda.

In the short-run, the analysis reveals that the GDP per capita exhibits a negative effect with no statistical significance. This suggests that GDP per capita may not have a substantial short-run impact on renewable energy consumption. In other words, changes in GDP per capita do not appear to have a significant effect on renewable energy consumption in the short run. This finding implies that other factors may play a more influential role in determining renewable energy consumption patterns in the short run.

Additionally in the short run, GDP per capita may have no significant impact on renewable energy consumption because initial economic growth is often driven by traditional energy sources like fossil fuels, leading to increased energy demands without a corresponding shift towards renewables. Also In the short term, industries and households may prioritize immediate energy needs over long-term sustainability, resulting in a disconnect between economic growth and renewable energy adoption. Furthermore, change in energy consumption patterns are often shaped by long-term factors like infrastructure and habits, which can make renewable energy investments and policies seem unrelated to short-term economic growth. This may better be explained by the study of (Apergis et al., 2020; Acemoglu et al., 2019; Stern, 2019), which suggest that the transition to renewable energy may lead to high initial economic costs, but

ultimately result in long-term benefits such as reduced energy costs and increased energy independence.

This study result in the short-run contradicts Wang et al. (2020) who found a positive and significant relationship between economic growth and renewable energy consumption, it also differs from Apergis et al. (2018) who discovered a positive and significant relationship between economic growth and renewable energy consumption in most studies.

However, in the long-run, the results show that the Gdp Percapita is positive and statistically significant, indicating a long-run relationship between GDP per capita and renewable energy consumption. This suggests that as GDP per capita grows, renewable energy consumption also increases in the long run. This finding implies that economic growth, as measured by GDP per capita, is associated with an increase in renewable energy consumption over time. This could be due to various factors, such as increased investment in renewable energy technologies, improved energy efficiency, or changes in consumer behavior. This long-run relationship highlights the importance of considering the interplay between economic growth and renewable energy consumption in shaping a sustainable energy future.

Furthermore, in the long run, as GDP per capita continues to rise, several dynamics can change. Increased wealth often leads to greater investment in infrastructure, including renewable energy technologies. Higher income levels can also enable both individuals and governments to invest in cleaner energy sources, spurred by both consumer demand for sustainable options and policies promoting green energy.

These findings align with previous studies of Ozcan et al. (2019) who discovered a positive and significant relationship between economic growth and renewable energy consumption in OECD

countries. It was also consistent with Al-Mulali et al. (2015) who found a positive and significant relationship between economic growth and renewable energy consumption in the long run.

The study finds a highly significant effect of GDP per capita on renewable energy consumption in the long run, consistent with previous studies (Sadorsky, 2009; Pfeiffer and Mulder, 2013; Nicholas et al., 2014; Stamatios et al., 2018). This suggests that economic growth drives the adoption of renewable energy sources. This study result in the long are consistent with Wang et al. (2020) who found a positive and significant relationship between economic growth and renewable energy consumption, it also differs from Apergis et al. (2018) who discovered a positive and significant relationship between economic growth and renewable energy consumption in most studies.

Overall, the relationship between renewable energy consumption and GDP per capita is complex and dependent on various factors, including context, pace, and timing of the transition.

Objective two: Examining the effect of carbon dioxide emissions on renewable energy consumption in Uganda.

The relationship between renewable energy consumption and carbon dioxide emissions is complex, with both short-term and long-term effects.

In the short-run analysis, the results show that carbon dioxide emissions has a positive but not statistically significant effect on renewable energy consumption. This finding suggests a potential correlation between carbon dioxide emissions and renewable energy consumption, implying that increases in carbon dioxide emissions may be associated with increases in renewable energy consumption. However, the insignificance of the relationship coefficient necessitates further investigation to understand the nature of this relationship as a result more

empirical analysis was done, such as Granger causality testing or error correction modeling, to provide valuable insights into the short-term dynamics between carbon dioxide emissions and renewable energy consumption and later the long run.

This short-run result contradicts Apergis et al. (2019) who found a positive and significant relationship between carbon dioxide emissions and renewable energy consumption in OECD countries.

The findings of Al-Mulali et al. (2015) who discovered a positive and significant relationship between carbon dioxide emissions and renewable energy consumption in a panel of countries also Contradicts the short-run result.

However, in the long-term, our analysis reveals a statistically significant positive effect of carbon dioxide emissions on renewable energy consumption, suggesting that efforts to reduce carbon dioxide emissions may also lead to increased renewable energy consumption. This finding supports existing literature that highlights the importance of considering long-term effects and the role of energy efficiency in reducing carbon dioxide emissions (Sadorsky, 2009; Bengochea and Faet, 2012; Apergis and Payne, 2014a, 2014b; Omri et al., 2015; Al-Mulali et al., 2016; Saboori et al., 2017).

The positive relationship between carbon dioxide emissions and renewable energy consumption in the long-term can be explained by several factors. Policy responses to increasing carbon dioxide emissions, such as implementing renewable energy targets or carbon pricing, may play a role (Apergis et al., 2020; Acemoglu et al., 2019; Stern, 2019). Additionally, the virtuous cycle of increasing renewable energy consumption leading to reduced carbon dioxide emissions, as well as technological advancements, changes in energy consumption patterns, and economic

growth, may also contribute to this relationship (Sadorsky, 2009; Bengochea and Faet, 2012; Apergis and Payne, 2014a, 2014b; Omri et al., 2015; Al-Mulali et al., 2016; Saboori et al., 2017).

Our study's findings emphasize the importance of considering both short-term and long-term effects when evaluating the relationship between renewable energy consumption and carbon dioxide emissions. In other wards the discrepancy between the short-run and long-run aspects highlights the importance of considering both short-run and long-run dynamics when analyzing the relationship between carbon dioxide emissions and renewable energy consumption.

By understanding the complex dynamics at play, policymakers and researchers can better design policies and strategies to reduce carbon dioxide emissions and promote sustainable energy development. Our study contributes to existing literature by highlighting the importance of a long-term perspective in evaluating the effectiveness of renewable energy consumption in reducing carbon dioxide emissions.

Objective three: Assessing the effect of access to electricity on renewable energy consumption in Uganda.

In the short Run, the results of Access to electricity shows a negative relationship between renewable energy consumption and access to electricity, implying that an increase in access to electricity does not necessarily lead to an increase in renewable energy consumption. However, this relationship is not statistically significant ($z = -0.9$ and $P > 0.37$), suggesting that access to electricity and renewable energy consumption are not closely related, and other factors may be influencing renewable energy consumption. Additionally, access to electricity was omitted from the analysis as it became collinear.

Our study is consistent with the literature, which suggests that access to electricity and renewable energy consumption become increasingly intertwined as economies transition towards more sustainable energy systems (Seyboth et al., 2019). According to Omri et al., 2015 ,in the long-run the relationship between access to electricity and renewable energy consumption becomes redundant or highly correlated with the error term, or changes in energy consumption patterns.

However, contradicts some studies for instatance Empirical studies have shown that increasing access to electricity leads to increased renewable energy consumption (Apergis & Payne, 2019), The relationship between access to electricity and renewable energy consumption is complex and bidirectional (IEA, 2019). Access to electricity is a necessary precursor to renewable energy consumption, enabling connection to the grid and utilization of renewable energy sources (World Bank, 2018). Conversely, renewable energy consumption contributes to increased access to electricity, providing a clean and sustainable source of energy (IRENA, 2019).

Including Access to Electricity in the analysis could provide valuable insights into how access to electricity affects renewable energy consumption in Uganda. It's possible that increased access to electricity could lead to increased renewable energy consumption, as more people and businesses have the ability to access and use renewable energy sources. However, the actual relationship may be more complex, and there may be other factors at play.

Since hydroelectric power accounts for a substantial share of renewable energy in Uganda, any constraints in accessing hydroelectricity can have a ripple effect on the overall renewable energy consumption in the country. In Uganda, electricity is primarily generated from hydro energy, which can affect the consumption of other renewable energy forms like solar PV, thermal, and wind.

Despite various on-grid and off-grid electricity solutions to increase access to electricity for productive use, high upfront costs and high electricity tariffs remain significant barriers. For instance, the current tariff of Shs882 per kilowatt-hour is extremely high and has led to a decline in electricity consumption. Although the Electricity Regulatory Authority (ERA) reduced tariffs in the Second Quarter of 2023, the rates remain high for various consumer categories, leading to decreased hydroelectricity consumption and increased use of non-renewable sources like diesel power generators and any other traditional energy sources such as burning oils and imported coal.

Objective Four: Examining the effect of Human Development Index on renewable energy consumption.

In the short-run, the study results show that Human Development Index shows a negative and significant relationship between human development Index and renewable energy consumption. This suggests that in the short term, an increase in human development is associated with a decrease in renewable energy consumption. This finding is intriguing, as it contradicts the intuitive expectation that higher human development index would lead to increased renewable energy consumption.

However, this finding is consistent with previous studies that have identified a similar negative relationship between human development and renewable energy consumption in the short term (e.g., Apergis et al., 2019; Al-Mulali et al., 2015). Apergis et al. (2019) found that in the short term, human development is negatively related to renewable energy consumption, suggesting that countries with higher human development may prioritize economic growth over renewable energy adoption. Similarly, Al-Mulali et al. (2015) discovered that human development is negatively associated with renewable energy consumption in the short run, possibly due to the

increased energy demands that come with economic growth and are met primarily through traditional energy sources as communities may prioritize immediate economic development over sustainability, leading to a temporary decrease in renewable energy consumption.

One possible explanation for this negative relationship is that as countries develop economically, their energy needs increase, and they may rely more heavily on fossil fuels to meet those needs, leading to a decrease in renewable energy consumption. Additionally, the results may also suggest that countries with higher HDI may have already reached a threshold of renewable energy adoption, and further development does not necessarily lead to increased renewable energy consumption. Therefore as nation continues to develop and improve its HDI, the negative impact on renewable energy consumption can persist if the focus remains on economic growth without sufficient investment in sustainable energy policies. Higher income levels can lead to greater energy consumption overall, and if the energy mix continues to favor fossil fuels as observed in Uganda, renewable energy usage may instead decline. This phenomenon is known as the "energy intensity paradox" (York, 2012).

In the long run however, the results still indicated a statistically significant negative relationship between human development index (HDI) and renewable energy consumption. Our findings contradict the findings of Apergis et al. (2019) who discovered a positive and significant relationship between human development and renewable energy consumption. The study results also differ from Wang et al. (2020) who found a positive and significant relationship between human development and renewable energy consumption.

These findings have important implications for policymakers, as they suggest that relying solely on economic development to drive renewable energy adoption may not be sufficient. Instead,

targeted policies and investments in renewable energy infrastructure, technology, and education may be necessary to promote sustainable energy development and reduce carbon emissions.

In conclusion, the relationship between human development and renewable energy consumption is complex and multifaceted. While our results suggest a negative relationship between HDI and renewable energy consumption both in the short and long run, this finding should not be interpreted as a deterministic outcome. Rather, it highlights the need for policymakers to adopt a more nuanced approach to promoting sustainable energy development.

Objective five: Assessing the influence of Trade openness on renewable energy consumption in Uganda.

Our results show that the relationship between trade openness and renewable energy consumption is not statistically significant in the short run. However, the negative relationship suggests that an increase in trade openness may lead to a decrease in renewable energy consumption. This finding may be surprising, as trade openness is often expected to promote the adoption of renewable energy technologies through increased access to international markets, technology transfer, and investment. However, the insignificance of this relationship may be due to various factors that dominate the relationship like this could be partly attributed to the fact that in the early stages of increased trade, the effects on renewable energy consumption might not be immediately observable it may take time for industries and consumers to adapt to new technologies and practices. Consumers may continue relying on traditional energy sources until they can effectively integrate renewable alternatives into their energy mix this might bring a disconnect between Trade openness and Renewable energy consumption.

The findings of this study align with the existing literature on the relationship between trade openness and renewable energy consumption which is consistent with previous studies indicating

that trade openness may not have a significant impact on renewable energy consumption in the short term, as also suggested by Apergis et al. (2018).

In the long-run, the results show a statistically significant but negative relationship between Trade Openness and Renewable Energy Consumption in the long run. This finding suggests that trade openness may not necessarily lead to an increase in renewable energy consumption, as one might expect in the long-run instead, it may lead to an increase in overall energy consumption, including non-renewable sources, or may not have a significant impact on renewable energy consumption.

Our results show that the relationship between trade openness and renewable energy consumption is not statistically significant in the short run, which is consistent with previous studies (Aïssa et al., 2014; Shahbaz et al., 2014). However, the negative relationship suggests that an increase in trade openness may lead to a decrease in renewable energy consumption, which contradicts the expectations of trade openness promoting renewable energy adoption (Yanikkaya, 2003; Semancikove, 2016). This finding also contradicts the notion that trade openness can lead to increased renewable energy consumption in the long run, as suggested by previous research such as Al-Mulali et al. (2016) and Jebli et al. (2019).

Additionally, in most developing countries like Uganda, this energy demand is met primarily through fossil fuels rather than renewables, resulting in a long-term reduction in renewable energy consumption.

Overall, this study contributes to the existing literature by providing new insights into the dynamic relationship between trade openness and renewable energy consumption, highlighting the importance of considering both short-run and long-run effects.

5.1 Conclusion

This study was intended to establish the determinants of renewable energy consumption in Uganda. Notably, several studies have been conducted to establish the determinants of renewable energy consumption across the world. However, conflicting results have been reported whereby, in some studies significant results were obtained while in other studies the same factors were not significant; and this difference was particularly identified between the developed and less developed countries. Therefore, this study aimed at examining the effect of GDP per capita, carbon dioxide emissions, access to electricity, human development index and Trade openness on renewable energy consumption in Uganda using a quantitative time series approach.

In conclusion, this study examined the relationships between renewable energy consumption and several macroeconomic variables in Uganda, the findings revealed complex relationships between these variables, with both short-term and long-term effects: -

In the short term, the study found a negative relationship between renewable energy consumption and GDP per capita, suggesting that high initial costs of renewable energy projects may lead to a temporary decrease in economic growth. However, in the long term, the relationship becomes positive, indicating that economic growth can drive the adoption of renewable energy sources.

The study also found a positive relationship between carbon dioxide emissions and renewable energy consumption in the long term, suggesting that efforts to reduce emissions may lead to increased renewable energy consumption.

Additionally, the study found a negative relationship between access to electricity and renewable energy consumption, suggesting that increasing access to electricity may not necessarily lead to increased renewable energy consumption. The results showed that access to electricity has a non-significant negative relationship with renewable energy consumption. However, this small

negative relationship could be a random effect of the negative trend of the consumption of renewable energy established from the time series data on renewable energy consumption in Uganda, which gives no causation effects between the two variables. Partly the high tariffs of electricity, inspite of the growing levels of access to electricity, hinder consumption of grid-based electricity especially form hydro power plants, as people will always opt for cheaper energy sources which may sometimes be conventional and environmentally unfriendly thus the possible explanation to the negative relationship between these two variables.

Furthermore, the study found a negative relationship between human development index and renewable energy consumption in the long term, indicating that Human Development Index is not necessarily associated with renewable enrgy Consumption but has a signicant effect in the long run.

Finally, the study also found a negative relationship between trade openness and renewable energy consumption in the long run but the relationship is significant, suggesting that trade openness may not necessarily lead to increased renewable energy consumption, there are other factors in play..

Overall, this study highlights the importance of considering both short-term and long-term effects when evaluating the relationships between renewable energy consumption and macroeconomic variables. The findings have important implications for policymakers and researchers, suggesting that investments in renewable energy, human development, and trade openness can have synergistic effects in the long run, supporting the transition to a more sustainable energy mix.

5.2.1 Recommendation

The findings of this study provide a basis for policy-making for Uganda in the following context:

The government through Ministry of energy and mineral development should consider implementing policies that promote renewable energy adoption, such as tax incentives, feed-in tariffs, and net metering laws. Additionally, investing in energy efficiency measures and grid expansion can also help increase renewable energy consumption. By doing so, Uganda can decouple economic growth from fossil fuel consumption and ensure a sustainable development pathway."

To promote renewable energy consumption in Uganda, the government through Ministry of energy and mineral development should prioritize increasing access to electricity, particularly in rural areas. This can be achieved through the development of off-grid renewable energy solutions such as solar and wind power. Additionally, the government should implement policies to reduce carbon dioxide emissions, such as promoting energy-efficient technologies and encouraging the use of renewable energy sources. This can be done through initiatives such as tax incentives for businesses that adopt renewable energy technologies and public awareness campaigns to promote sustainable practices.

Economic growth strategies should be aligned with renewable energy development to ensure that economic expansion does not come at the expense of environmental sustainability. This can be achieved through the development of policies that promote the use of renewable energy in industries such as manufacturing and transportation. Furthermore, trade policies should be designed to promote the importation of renewable energy technologies and encourage foreign investment in the renewable energy sector. This can be done through the reduction of tariffs on renewable energy technologies and the provision of incentives for foreign investors.

To promote private sector investment in renewable energy, the government through ministry of trade and Commerce should provide incentives such as tax breaks or subsidies for renewable energy projects. Additionally, the government through ministry of energy and mineral development should establish a dedicated agency or department to oversee the development and implementation of renewable energy policies and programs. This agency can provide technical assistance and support to private sector investors and ensure that renewable energy projects are aligned with national development goals. Moreover, research and development in renewable energy technologies should be prioritized to improve their efficiency and reduce costs.

Finally, international cooperation and partnerships should be pursued to access global knowledge, technologies, and funding for renewable energy development. This can be achieved through the development of partnerships with international organizations and countries that have experience in renewable energy development. Additionally, regular monitoring and evaluation of renewable energy consumption and production should be conducted to track progress and identify areas for improvement. This can be done through the establishment of a monitoring and evaluation framework that tracks key indicators such as renewable energy consumption, greenhouse gas emissions, and private sector investment in renewable energy.

5.2.2 Area for further research

Further research is needed to fully understand the relationships between renewable energy consumption and macroeconomic variables. One area of further research is to investigate the dynamic relationships between renewable energy consumption and macroeconomic variables using advanced econometric techniques. Additionally, country-specific analysis and sectoral analysis could provide a more nuanced understanding of the relationships between renewable energy consumption and macroeconomic variables.

Another area of further research is to examine the relationships between renewable energy consumption and energy security measures, environmental impacts, and public perception. Investigating the challenges and opportunities of integrating renewable energy sources into the grid and the role of energy storage technologies in promoting renewable energy adoption could also provide valuable insights. Furthermore, analyzing the impact of international cooperation and trade on renewable energy adoption and the relationships between renewable energy consumption and climate change mitigation strategies could be beneficial.

Finally, researching the relationships between renewable energy consumption and sustainable development goals, energy efficiency measures, and economic growth could provide a more comprehensive understanding of the impacts of renewable energy consumption. Investigating the effectiveness of policies aimed at promoting renewable energy adoption and reducing carbon emissions could also inform policy decisions. Overall, further research is necessary to fully understand the complex relationships between renewable energy consumption and macroeconomic variables and to inform strategies for a sustainable energy transition.

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