UNIVERSITY of RWANDA COLLEGE OF SCIENCE AND TECHNOLOGY ACE-ESD AFRICAN CENTER OF EXCELLENCE IN ENERGY FOR SUSTAINABLE DEVELOPMENT

TITLE OF THE THESIS: ENERGY CONSUMPTION AND ECONOMIC GROWTH IN RWANDA

Thesis number: ACEESD/EEC/21/25

Aresearch project Submittedto the African Center of Excellence in Energy studies for sustainable development (ACE-ESD)

In partial fulfillment of the MASTERS OF SCIENCE IN ENERGY ECONOMICS degree requirement

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November, 2021

Kigali-Rwanda

DECLARATION

I, Uwizeye Naome, declare that the work "Energy Consumption and Economic Growth in Rwanda" is my individual research, there is no other one who has done this research or submitted it to the University of Rwanda or any other university, and that it was completed under my supervision.

Date: November 15, 2021

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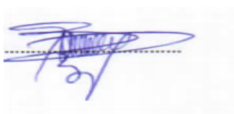

Uwizeye Naome

This thesis has been submitted for examination with my approval as a university advisor.

Thesis advisor: Dr. KABANDA RICHARD

Signature:

DEDICATION

To my God,

To my belovedfamily, my lovely husband HITIMANA Bienfait,

To my children Gwiza Micah Ethan and Iliza BlessAlmah

To all my relatives and friends

To Dr. KABANDA Richardforunconditional support to attain postgraduate studies

ACKNOWLEDGEMENT

First of all, Iwould like to appreciate and to thank so much my loving husband, who served as my work advisor and contributed significantly to my study.

I thank also my research′s supervisor, Dr. KABANDA Richard, because he devotes a lot of his time to the work of supervision. His great mentoring was vital in completing this postgraduate program.

In addition, let’s thank all of the lecturers, classmates, and friends who have helped me advance my knowledge and education.

I want also to thank the World Bank/ACEESD and the UNIVERSITY OF RWANDA, College of Science and Technology, for their support of this postgraduate study.

ABSTRACT

Energy is a critical ressource for the economy.Energy resources are the most important sources of production that can help to grow the economy, particularly in high-energy-intensive countries. The importance of energy is considered as a source of country's output. Economic growth can be defined as the boosting of a country's output throughout goods and services over time. This study was seek to indentify causalitiy linkage between energy usage and economic growthof Rwanda as a developing country in short period or in the long period. The study used data from 1990 to 2019, the cointegration and the vector error correction (VECM)methods was used as the analysis approach. The results showed that a standard deviation shocks to renewable energy usage has a negative effect in short-termon real GDP but in the positive side and a negative effect in long-termon real GDP but in the negative side. However, in the period of short and long, the shock to nonrenewable energy usage has a positive impact on the real GDP, proving that with either energy consumption or real GDP as a dependent variablesare more significantly, Rwanda has previously proven its ability to create, deploy, reproduce, and scale up renewable energy consumption by increasing its contribution to complete energy access. Encouragement of renewable energy consumption particular with respect the deployment of clean technologies that incorporate renewable energy into manufacturing processes, could boost economic growth.

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ABBREVIATIONS AND ACRONYMS

UR: University of Rwanda

CST: College of Science and Technology

ACEESD: African Centre of Excellence in Energy for Sustainable Development

VECM: Vector Error Correction Model

AIC: Akaike Information Criterion

SBIC:Schwarz's Bayesian Information Criterion

HQIC: Hannan- Quinn Information Criterion

PP: Phillips and Perron

TJ: Terajoule

GJ: Gigajoule

MW: Megawatt

ADF: Augmented Dickey-fuller

ERS:Ellott-Rothenberg-Stock

WDI: World Development Indicators

NREc: Non- Renewable Energy Consumption

REc: Renewable Energy Consumption

LPG: Liquid Petroleum Gas

GDP: Gross Domestic Product

GDI: Gross Domestic Investment

OECD:Organization for Economic Co-operation and Development

AEA:Austrian Energy Agency

IMF: International Monetary Fund

MININFRA: Ministry of infrastructure

USD: United States Dollar

R&D: Research and Development

GNP: Gross National Product

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1. GENERAL INTRODUCTION

1.1 INTRODUCTION

1.1 Background of the study

Energy is a critical resource for the economy. Every aspect of economic activity on this planet needs energy in one form or another to function properly(Chinedu et al., 2019). The world's annual consumption of energy per capita was approximately 50,000 GJ per day by the end of the 20th century. Some 80% of the fossil fuel consumption, coal, oil, and natural gaswere represented by organic sources. Nuclear energy accounted for 6% and hydropower for 2%. This 8% contributed to the energy balance non-organically. The other 12 % was made up of human food and livestock (now a marginal source of energy) as well as firewood, which is exclusively consumed in developing countries (Malanima, 2015).

Rwandan economy was affected by Genocide against Tutsi in 1994, but the government of Rwanda tried to stabilize its economy after. In the manner of restoring the country to overcoming that crisis of the Genocide, the energy sector was essential in the country's economic development. According to Rwanda's Minister of Infrastructure, the government is committed to achieving universal electricity access by 2024 and mobilizing the necessary funds to achieve the goal. “Installed capacity has increased from 97MW in 2010 to 225MW today, with more than 300MW expected to be on the grid by 2024(MININFRA, 2020).Rwanda's energy balance revealed that the biomass has 85 % of energy use, with 99 % of all homes using biomass for cooking, petroleum products has 11 %, and 4% on hydro sources. Rwandans consume more energy in their homes, businesses, industries and transportations of personnel and goods(Rwanda Energy Situation,2020).

Over the past decade, Rwanda's economy has grown at a tremendous step. Rwanda achieved a significant advancement in rebuilding and balancing its wealthy, surpassing pre-genocide levels, thanks to a government that has achieved both sustainable and increased economic growth. The economy as a whole is expanding rapidly. From 2005 to 2009 the average annual GDPrate was 8.8%.the GDP per capita of Rwanda was rise from $200 in 1994 to $818.99 in 2020. The Government of Rwanda has mapped a path for Rwanda's economic development, even though it is still in its early phases (Malunda & Musana, 2012).

Energy resources are important sources for production which may grow the economy specifically for countries that are highly energy-intensive(SEk, 2017). The significance of energy as a source of economic growth is well known. For any country, economic growth is described as a rise in the production of products and services during a given time period. In reality, the energy industry contributes to long-term economic growth through its essential products.

Rwanda has a five major energy-consuming sectors: The industrial sector includesmanufacturing, agriculture, mining, and construction facilities and equipment, transportation includes vehicles that transport people or goods; residential includes households and apartments; and commercial includes the commercial area, as well as their equipment; and the electric power sector produces the majority of the electricity consumed by the other four sectors. Energy consumption is large and connected with GDP, making it a vital economic resource. On the other hand the relationship between energy and economic growthhas a wide range of consequences. If energy growth affects economic growth rather than the other way around, then a rise in energy consumption is required to boost and stimulate economic growth(Chinedu et al., 2019).

Rwanda's Vision 2050 lays out a clear path to reach high economic status by 2050. Energy will help Vision 2050 be realized by providing residents and industrial users with more cheap and dependable access to electricity, securing the sustainability of LPG supply, and ensuring petroleum supplies. International experience has demonstrated that economic progress is not possible without a functioning energy sector, along with minimum capacity and consumption levels, in addition to encouraging the improvement of the other energy sources such as renewable energies and wood fuel end use technologies in order to sustain and to protect woodlands and the environment (Ministry of infrastructure, 2018).

1.2 Statement of the Problem

Electricity is being more widely used and drives the growing of the Rwanda's economy, However, it only accounts for a small ratio of 4% of total energy consumed due to the high cost of electricity in rural areas and the high cost of hydropower power plants. In contrast, biomass accounts for 85 % of cooking fuel, rural households utilize wood, while urban households use charcoal. due to a lack of alternatives to biomass for cooking, such as LPG and biogas.

Petroleum accounts for 11% of total energy consumption in the country, but storage capacity for petroleum is still insufficient (Ministry of infrastructure, 2018).

1.3 Objectives of the study

1.3.1 General Objective

The aim of this study is to look at the linkage between energy consumption and Rwanda's economic growth from 1990 to 2019.

1.3.2 The Specific Objective

- ✓ To identify the level to which renewable energy consumption affects Rwanda's output in the long run
- ✓ To identify the level to which non-renewable energy consumption affects Rwanda's output in the long run
- ✓ To identify the level to which renewable and non-renewable energy affects Rwanda's output in the short-run

1.4 Scope of the study

The purpose of this research is to identify and classify the causality linkage between energy components usage and GDP in order to evaluate the effect of energy consumption on the Rwanda's output. To compile the overall data for this study, the data was used they came from the platform of WDI online data. The required data for each variable under consideration ranged from 1990 to 2019. This study was carried out using the VECM (Variable Error Correction Model) developed in the methodology chapter.

1.5 Expected Outcomes and Significance of the Study

1.5.1 The expected outcome of the study

This study shows how energy consumption has the highest or least impact on Rwanda's economic growth, and how increasing the use of energy components contributes to Rwanda's economic growth.

1.5.2 Significance of the Study

This research is significant because it gives a sense of how the consumption of energy by households, industries, and commercialized areas contribute to the economic growth of Rwanda. This study examines whether energy consumption has the biggest or least impact on Rwanda's economic growth.

Moreover, the next researchers will benefit from the knowledge from this research and use it as a reference. The researcher will benefit from this research because its completion will allow the researcher to get a Master's Degree in Energy Economics. The government will benefit the results from this study because it will help to develop alternative energy sourcesand will recommend setting out the policy of reducing reliance on wood in the rural area and charcoal in the urban area in the way of developing biomass energy strategy. This study also will suggest the government increase the infrastructure in energy consumption to achieveRwanda's vision 2050.

2 LITERATURE REVIEW

2.1 Definition of the key concept

2.1.1 Energy consumption

All energy used for action, production, or the inhabitants of a building is referred to as energy consumption. Energy is consumed for a secondary purpose rather than for the sole purpose of consuming it (e.g. for the purpose of mobility, the production of goods and services, or the attainment of a specific level of comfort). Users do not consume energy directly, but rather profit from a variety of long-lasting appliances and equipment (Schwarz, 2017).

2.1.2 Economic growth

After price increases is taken into account, economic growth is caused by a rise in the market value of an economy's goods and services over time. Statisticians frequently use the percentage rate of increase in real gross domestic product to measure such growth (IMF, 2012).

In most cases, the increase in harvested outputs associated with the removal of inflation's distorting influence on the pricing of products produced is expressed in real terms, i.e. income growth terms. Economic growth is measured using national income accounting. As a result, economic growth can be defined as the annual percent change in GDP, which includes all of the advantages and disadvantages of that metric (Goldon.R.Junior, 2013).

Economic growth is on the rise, and changes in a country's ability to expand production through capital, labor, and technology, such as labor efficiency, can indicate an increased level of research and development An increase in outputs and the ability to produce these outputs is defined as economic growth (Solow, 1978).

2.2 Theoretical review

2.2.1 Economic growth and energy consumption theories

The name Joseph Schumpeter serves as a starting point for an examination of economic growth theory. Unlike the classics, Joseph Schumpeter did not consider that capital accumulation was the major source of economic growth. He emphasized the entrepreneur-innovator concept, referring to him as a "development hero." Entrepreneurial innovation and creativity, in his opinion, defined economic growth. Schumpeter concluded that economic growth was unbalanced, which he attributed to the "jump" in the economy (Schumpeter 1934. P. 65). The theory of economic growth is focused on the concepts of private property, a competitive market, and financial market efficiency.These conditions are frequently lacking in countries that lack a democratic structure. The theory of Schumpeter is intended for democrat and economic of the developed countries.

Arthur Lewis developed another economic growth theory. He addressed the issue of underdeveloped countries with a large labor force in his research (Lewis 1954, p. 3). Lewis recognized classical economics' broad vision but did not always agree with its diagnosis and methodology. In the short run, Lewis' model suggests maintaining a low quality of life. Savings will increase the capital stock, resulting in the emergence of long-term income growth. As a result, Lewis' model predicts that in fact for income levels to be equalized over time, short-term inequalities between countries must be increased (Lewis 1956, pp. 7-22).

Lewis' theory, on the other hand, involves difficult to accept assumptions. Poverty cannot be postponed off until some unspecified time in the future. After all, greater wealth gathering would necessitate lower consumption, which would disproportionately affect the poorest individuals.

The "Kuznets' curve" theory developed by Simon Kuznets provided a theoretical foundation for Lewis' thesis (Kuznets 1955, pp. 1-28). Economic inequalities exist in the early stages of growth, according to empirical studies. Initially, as workers began to reject farm labor in favor of industrial work, the differences were most visible. However, when production factors were concentrated in industrial hubs, the differences began to decline. In additional, Kuznets identified a positive link between the dynamics of economic expansion and the growing ration of the overall population who resided in urbanized city(Kuznets 1976, p. 32).

A few year ago, Walt Rostow established another theory of economic development. Rostow, like Lewis, identified five stages of development and based economic growth on capital accumulation (Rostow 1960, pp. 4-16). The most difficult challenge for poor countries, according to Rostow, is reaching the third stage, known as "take off." Poor countries are worried about breaking the "vicious circle" that has formed over time. Rostow advocated for circumventing it by amassing capital. He recognized, however, that if there were no opportunities to increase internal accumulation, external assistance would be required. Furthermore, shifting the economy from agrarian to industrial, according to Rostow, would allow economic growth to spread throughout the country. Rostow proposed the "quality" stage of economic growth in 1971,which isdescribed by continuous improvement in the quality of goods and services (Rostow 1971).

The overall economic effect of these operations can counterbalance the costing of utilizing energy resources in manufacturing and service business operations. Energy resources include material purchases and procurement related to energy resource usage. The residual and cumulative innovations of the previous mentioned businesses have a positive economic effect. Furthermore, the mentioned previously induced demand improvement in monetary transactions not only boosts the economy and increases people's living standards, but it may dynamically bring a series of innovative events on the part of businesses and relevant stakeholders that may lead to a lower accumulative cost of energy production, i.e., even if business clients or customers can pay for a decreased amount cost of energy production(Vosooghzadeh, 2020).

A county’s output is inextricably linked to energy usage, which is governed by energy supply. The industrial sector, for example, consumes nearly one-third of all global energy and accounts for the vast majority of economic activity(Austrian Energy Agency (AEA), 2014).

Energy is used in the manufacturing industry takes a wide range of activities which include processing and assembly, air conditioning systems, and lighting, according to the EIA (2011). However, this should be noted that energy consumption (particularly with regard to fossil fuels) has negative consequences such as pollutant emissions. As a result, country may choose pollution reduction measures like increasing energy efficiency by replacing fossil fuels like coal, gas, and oil with cleaner sources (including renewable energy) (Watson et al., 2010).

Economic theory development highlights several strategies for economic expansion despite a finite supply energy. Technological advancement and the substitution of energy for capital and labor inputs could allow current energy resources to be used more efficiently. New energy sources that are not constrained by binding supply limits could also provide new sources of growth(Solow, 1997).

Based on these principles, neoclassical model predicts that sources of energy are not important inputs to manufacturing. While energy resources are necessary in manufacturing, the causality chain leads from economic growth to energy use. As a result, energy supply constraints do not need to have an effect on the macroeconomic growth curve. The key policy implication is that energy conservation and economic growth can be collaborated.This assumption also implies that global living standard do not have to fall in order to address serious environmental challenges like climate change and impending fossil fuel shortages. Another theoretical approach, often associated with the ecological economics school of thought, contends that energy resources are a limiting factor in the growth of modern economies(Cleveland et al., 2004).

If specific energy supply limits are assumed, the implications for living standards are far less optimistic than the neoclassical approach. By drawing on numerous science principles and properties, the ecological economics school of thought claim that energy, widely interpreted, is the primary factor of production in economic systems(Georgescu-Roegen, 1975).

This theory focuses on the material foundation of economic production, from which several limits emerge in the theorical substitution and technological change arguments of neoclassical theory. To the extent that these constraints indicate a continuous reliance on energy resource inputs for economic growth, the opportunities for sustained economic growth under an energy resource scarcity system (or energy conservation regulations) differ significantly from mainstream theory’s expectations.

The physical interconnection of diverse inputs, according to one key argument in the ecological economics literature, limits the capacity of factors to replace energy. To the extent that capital item advancement and maintenance necessitate a flow of energy and materials, manufacturing of the substitute products necessitates a greater amount of the input-energy-for which it is substituting(Cleveland et al., 2004).

Shot-term economic balance, according to the theory, is the result of changing levels of labor and capital, both of which are important in the production process. According to the theory, technological improvement has a significant impact on the overall operation of an economy. Neoclassical growth theory outlines the three components required for a growing economy. Labor, capital, and technology are examples of these.

2.3 Empirical Review

Academics and researchers were interested to learn more about the linkage between energy usage and countries output. The subject under consideration is significant, and it should be treated to a detailed empirical study to stay current with the perspectives of interested academics and scholars on the subject, as well as to detect the gaps in previous relevant studies**.** (Odularu & Okonkwo, 2009) researched the linkage between the economy of Nigeria and energy usage shows that crude oil, electricity, and coal were the energy sources chosen to investigate this relation. A study has shown that there is a positive association between present period energy use and economic growth, except for coal, which had a negative association.

There was a negative relationship between lagged energy consumption and economic growth.The cointegration test results show a positive linkage between current period energy use and economic growth. Excluding coal, which had a positive relationship, there was a negative linkage between lag in energy consumption and economic growth(Babatunde Onakoya et al., 2013).

The empirical findings show that petroleum, electricity, and total energy use all have a strong and positive link with Nigerian economic growth(Belke, Ansgar; Dreger, Christian; de Haan, 2010)aimed to assess the ling-run linkage between energy consumption and real GDP in OECD countries between 1981 and 2007, including energy costs they used principal component analysis to demonstrate how international and national development account for the long-term relationship between energy usage and output of a country. There is no granger causation between electricity consumption and national economic performance in the primary sector. Foreign trends account for the majority of the longassociation between energy use and real gross domestic product. The results also show that the price for energy use does not change. They also concluded that there is a bidirectional causal link between energy use and economic development.

(Patrice.O, 2010)Cameroon's energy consumption and economic achievement were investigated. This study's findings show that there is no granger relationship between electricity consumption and national economic performance (GDP) in the primary sector. The results also revealed that granger manufacturing has an effect on electricity usage in the secondary sector. Furthermore, in the tertiary sector, the causation shifts from power consumption to production. He stated that any strategy aimed at stimulating the economy and alleviating poverty should prioritize energy generation.

(Sama & Tah, 2016)from 1980 to 2014, a study was conducted to determine the impact of energy usage on economic growth in Cameroon. The research made use of secondary time series data. The findings of the generalized method of moments approach show that GDP, population growth rate, and petroleum prices all have a positive relationship with petroleum usage. Furthermore, a positive link existed between GDP, population growth rate, power costs, and electricity usage. Another positive and significant link between petroleum use, electricity consumption, Gross Domestic Investment (GDI), population growth rate, and economic growth is revealed by the research. Furthermore, the empirical results showed a positive relationship between the rate of inflation and the rate of economic growth.

(Chinedu et al., 2019)from 1980 to 2017, a study was conducted to assess the effect of energy consumption on economic growth. According to the findings of the study, there is no long-run relationship between energy consumption and economic growth in Nigerian. It suggests that companies in charge of oil purification and transportation increase petroleum supply throughout the country.

Furthermore, while the links between energy use and economic growth have been studied for a long time, there is always room for improvement in ongoing research. Many different types of studied are being conducted to determine whether economic growth leads to increase energy consumption or vice versa. There is no consensus on the alleged increase in energy consumption. Many empirical studies have found a significant relationship between electricity use and economic growth (Babatunde Onakoya et al., 2013; Ongono, 2009).

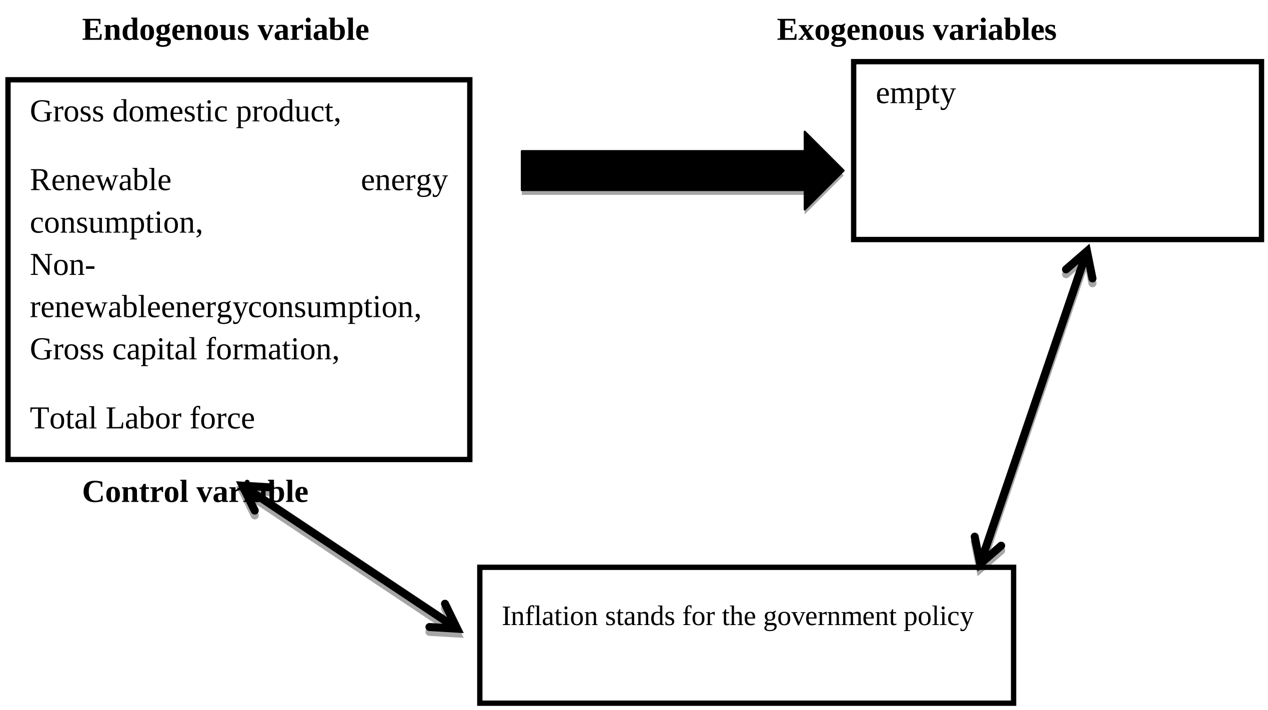
In support of the idea, there is evidence from an empirical study showing numerous researches have produced varying results, with some studies finding that energy consumption (Petroleum and electricity) has a positive and substantial influence on economic growth (Gbadebo, & Okonkwo, 2009; Ansgar et al., 2010; Adegbemi, Adegbemi, Olalekan, Babatunde, 2013). According to certain research, such as Adegbemi, Adegbemi, Olalekan, and Babatunde, 2013, liquefied natural gas usage in Nigeria has a favorable but small influence on economic growth and it has also a negative implication on the environment.

This study will improve on previous research by incorporating new factors. The primary issue that this study seeks to address is whether the components of Rwanda's energy consumption have a substantial impact on economic growth. However, the current research will consider GDP per capita, renewable and non-renewable energy consumption of selection bias.

2.4 Conceptual framework

The figurebelow shows that the framework which indicates the relationship between research variables namely endogenous, exogenous and control variables.

In addition, the determinant of energy consumption will be needed even if are mixed. But the research will highlight the following dependent variables influencing economic growth excluding the exogenous variables.



Source*: *Researcher's perception, 2021

The above figure indicated the conceptual framework which is the broad demonstration of variables that will be considered in the analysis. In this regard, the endogenous variable is the GDP (Gross Domestic Product) which is to be counted from 1990-2019, gross capital formation,the components of the energy consumed from 1990-2019 and total labor force. Moreover, the controlvariable is inflation stands for the government policy.

3 METHODOLOGY

3.1 Introduction

This section provides the Theoretical framework, Empirical model, data collection methods, source of data, data analysis method, variable specification, and hypothesis. The details are shown below:

3.2 Theoretical framework

The theoretical framework is essential for all studies to clarify the implicit theory in a more specified manner. It may also allow researchers to evaluate the research's limitations and other hypotheses that question the researcher's perspective. Using the Cobb-Douglas production as a framework, this part focuses on the theoretical and conceptual implications of the relationship between disaggregated energy consumption and economic growth.

The present thoughts of economic growth are mainly based on Solow's neoclassical growth model (1956). Energy is not a component of production in neoclassical economic models, and the economy is considered as a closed system in which goods are created by capital and labor inputs. However, in recent decades, there has been an increasing emphasis on the importance of energy as a component of production. The cobb-Douglas form is a commonly used production function that is recognized as an effective tool for determining the relationship between output and economic variables. It is expressed as:

$$Y_t = AK_t^{\alpha} L_t^{\beta} \qquad (3.1)$$

Where Y_t represents aggregate output at time t, K_t is capital, L_t is labor, and A is the technology parameter. $\alpha$and β measure the elasticities of output concerning capital and labor.

3.3 Empirical model

Capital, labor, technological advancement, and energy are the critical elements of economic growth in industrialized countries, according to recent research on the subject. As a findings, economic growth models are reliant on five variables: output, capital, energy, labor, and technological progress(Yuan et al., 2008). According to the recently research(Nourzad, 2000, Yuan et al., 2008, Mahaboob et al., 2019), This research becomes a production function for Cobb-Douglas in the following mathematical form, which includes energy as an input from the inputs of the capital: $Y_t = AK_t^{\alpha} Ec_t^{\gamma} L_t^{\beta} INF_t^{\emptyset}$ ______________ (3.2)

Where E_t is energy and γ is the elasticity of output concerning energy.

Energy is divided into two categories such as renewable energy consumption and non-renewable energy consumption, and the manufacturing method uses both types of energy (Liao et al. (2010) and Arbex and Perobelli (2010)). As a result, the above function is changed to:

$$Y_t = AK_t^{\alpha} REc_t^{\gamma 1} NREc_t^{\gamma 2} FEc_t^{\gamma 3} L_t^{\beta} \text{ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ } (3.3)$$

Where REc_t represents renewable energy consumption, $NREc_t$ represents non-renewable energy consumption, FEc_t represents final energy consumption.The production elasticity for renewable energy consumption, non-renewable energy consumption, and both is 1, 2, and 3, respectively. The logarithmic form of the production function yields a log-linear form, which is as follows: The production elasticity for renewable energy consumption, non-renewable energy consumption, and both is $\gamma 1$, $\gamma 2$, and $\gamma 3$, respectively. The production function's logarithmic form generates a log-linear form, as follows:

$$lnY_t = lnA + \alpha lnK_t + \gamma 1 lnREc_t + \gamma 2\, lnNREc_t + \gamma 3\, lnFEc_t + \beta \ln L_t + u_t \text{ \_\_ } (3.4)$$

In the above model, Y, represents real gross domestic production, K, stands for capital formation, L, stands for the total labor force, REc, stand for renewable energy consumption, NREc, stand for non-renewable energy consumption and FEc_t, stand for final energy consumption and, respectively. The economic explanations of α, β, $\gamma 1$, $\gamma 2$ and $\gamma 3$ are the elasticities of output concerning capital, final energy consumption, renewable and nonrenewable energy consumption and labor, respectively.

The model is a simplified version of a complicated reality that seeks to divide characters into little portions so that the relationship between them may be understood. The relationship between energy consumption and economic growth can be organized in the model by evaluating how all of these variables interact. This section explains the broad econometric methodologies utilized to analyze time-series data in this study. The features of the variables must be assessed in the empirical study to avoid incorrect regression. This study uses three separate unit root tests to accomplish this, as well as a sensitivity and robustness analysis.

3.4 Data collection methods

Data collection is the process of gathering and measuring information collected on the subject under consideration in a well-established system that can help one to answer the relevant questions. (Hart, 2005). In this regard, the online consultation was applied to collect data based on variables needed, and this was coupled with reading different past literature which emphasized similar studies and discovering what others have used in collecting information of concerns.

3.5 Source of data

The source of data is all about the area and material where the researcher collects data from the period of the research which is being carried out (Paige Wilson, 1989). The overall data in this research was gathered from the World development indicators (WDI) online data published by the World Bank. The required data on every variable under consideration was based on Rwandan records from WDI in the period from 1990-2019. The limitation in time (not including data from 2020 up to now) was due to the data available in the publication of World development indicators (WDI) where all the data related to the study were to be gathered.

3.6 Data analysis method

This research drives to assess the contribution of energy consumption on economic growth in Rwanda and its purpose is to categorize the causality relationship of energy components usage, Gross Domestic Product, gross capital formation, total labor force and inflation. The overall data in this research was collected from the World development indicators (WDI) online data published by the World Bank. The required data on every variable under consideration was based on the period from 1990-2019. This study is executed by using VECM model which is developed in the methodology chapter. The VECM, which has been utilized by other researchers in the energy sector (James, 2007), is used to test for causal relationships between different variables (Nicholas Apergis et Al., 2009). The VEC model has several benefits that make it more suited for testing causality effects in research. These benefits are as follows: VEC Model estimates are adaptable and less expensive in terms of information and time, and they allow for easy integration of new information.

3.6.1 Variable specification

the first step will be to perform an integration analysis using unit roots tests which are ADF test (Augmented Dickey-fuller), PP test (Philps inflpperron) and ERS (Ellott-Rothenberg-stock), the second step is to test for cointegration by using Johannsen's approach for each VECM constructed levels, the third step will be the test for causality using Engle and Granger test. The researcher was used a multivariate model in this study and three steps will be used to test the Engel and Granger causality:

The cointegration test was conduct under the below function of the model:

Gross Domestic Product= f (gross capital formation stands for capital), total final energy consumption, renewable energy consumption, non-renewable energy consumption, the total labor force stands for labor, and inflation stands for government policy).

$realgdp_{\text{t}}$= F (kapital, *tfec*, recn, nonrecn, tlf, infl). ____________ (3.5)

The variables are expected to be used by applying their natural logarithms to reduce the problem of heteroscedasticity. The equation in structural form can be written as follow:

$lnrealgdp_t = \beta_0 + \beta_1 ln\text{kapital}_t + \beta_2 lntfec_t + \beta_3 ln\text{recn}_t + \beta_4 ln\text{non\_recn}_t + \beta_5 \ln tlf_t + \beta_6 infl_t + u_t$ ________ (3.6)

Where, β_0 , $\beta_1, \beta_2, \beta_3, \beta_4$, $\beta_{5,} and\ \beta_6$ are elasticities of output; $realgdp_t$, as an endogenous variable, represents real gross domestic production at time t, capital, *tfec,* recn, nonrecn, tlf, infl, as endogenous variables, gross capital formation stands for capital, total final energy consumption, renewable energy consumption, non-renewable energy consumption,total labor force stands for labor and inflation stand for government policy.

The presence of a unit root is the null hypothesis in all of these tests, showing non-stationarity, while the absence of a unit root is the alternative hypothesis, implying stationarity. This study employs error correction based on Westerlund's (2007) cointegration tests. Because the tests are based on the structural dynamics and use no cointegration as the null hypothesis, no common factor constraint is used. The null is tested in a conditional error correction model by determining if the error correction term is equal to zero. The null hypothesis of no cointegration is also rejected if the null hypothesis of no error correction is rejected.

The vector error correction model to be estimated has the following mathematical form:

$\Delta lnrealgdp_t = \beta_1 + \beta_{11} V_{t-1} + \sum_{i=1}^{d} \gamma_{1i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{1i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{1i} \Delta lntfec_{t-i} + \sum_{i=1}^{d} \varphi_{1i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \rho_{1i} \Delta lnnorecn_{t-i} + \sum_{i=1}^{d} \emptyset_{1i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{1i} \Delta infl_{t-i} + \varepsilon_{1t}$ ____________ (3.7)

$\Delta lnkapital_t = \beta_2 + \beta_{21} V_{t-1} + \sum_{i=1}^{d} \gamma_{2i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{2i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{2i} \Delta lntfec_{t-i} + \sum_{i=1}^{d} \tau_{2i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{2i} \Delta lnnorecn_{t-i} + \sum_{i=1}^{d} \emptyset_{2i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{2i} \Delta infl_{t-i} + \varepsilon_{2t}$ ________ (3.8)

$\Delta lntfec_t = \beta_3 + \beta_{31} V_{t-1} + \sum_{i=1}^{d} \gamma_{3i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{3i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{3i} \Delta lntfec_{t-i} + \sum_{i=1}^{d} \tau_{3i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{3i} \Delta lnnorecn_{t-i} + \sum_{i=1}^{d} \emptyset_{3i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{3i} \Delta infl_{t-i} + \varepsilon_{3t}$ ___________ (3.9)

$\Delta lnrecn_t = \beta_4 + \beta_{41} V_{t-1} + \sum_{i=1}^{d} \gamma_{4i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{4i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{4i} \Delta lntfec_{t-i} + \sum_{i=1}^{d} \tau_{4i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{4i} \Delta lnnorecn_{t-i} + \sum_{i=1}^{d} \emptyset_{4i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{4i} \Delta infl_{t-i} + \varepsilon_{4t}$ ___________ (3.10)

$\Delta lnnon\_recn_t = \beta_5 + \beta_{51} V_{t-1} + \sum_{i=1}^{d} \gamma_{5i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{5i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{5i} \Delta ln\, tfec_{t-i} + \sum_{i=1}^{d} \tau_{5i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{5i} \Delta lnnon\_recn_{t-i} + \sum_{i=1}^{d} \emptyset_{5i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{5i} \Delta infl_{t-i} + \varepsilon_{5t}$ ___________ (3.11)

$\Delta lntlf_t = \beta_6 + \beta_{61} V_{t-1} + \sum_{i=1}^{d} \gamma_{6i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{6i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{6i} \Delta lntfec_{t-i} + \sum_{i=1}^{d} \tau_{6i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{6i} \Delta lnnon\_recn_{t-i} + \sum_{i=1}^{d} \emptyset_{6i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{6i} \Delta infl_{t-i} + \varepsilon_{6t}$ ___________ (3.12)

$$\Delta infl_t = \beta_7 + \beta_{71} V_{t-1} + \sum_{i=1}^{d} \gamma_{7i} \Delta lnrealgdp_{t-i} + \sum_{i=1}^{d} \delta_{7i} \Delta lnkapital_{t-i} + \sum_{i=1}^{d} \pi_{7i} \Delta ln\, tfec_{t-i} + \sum_{i=1}^{d} \tau_{7i} \Delta lnrecn_{t-i} + \sum_{i=1}^{d} \varphi_{7i} \Delta lnnon\_recn_{t-i} + \sum_{i=1}^{d} \emptyset_{7i} \Delta lntlf_{t-i} + \sum_{i=1}^{d} \omega_{7i} \Delta infl_{t-i} + \varepsilon_{7t}$$

___________ (3.13)

Where V_{t-1}reflects the model's vector error correction term there are two types of causality: long-run causation, which is caused by the vector error correction term if it is 0; and short-run causation, which is caused by the vector error correction term if it is 1. The second type of causality is short-term causation, which is represented by lagged dynamic terms.

3.6.2 Hypothesis test

Two causality tests should be utilized because there are two sources of causation: The Granger Non-Causality Test and the Long Run Weak Exogeneity Test.

3.6.2.1 Hypothesis test in short-run

Null hypothesis by employed Wald test Ho: For all $\gamma_{1i} = 0, \delta_{1i} = 0, \varphi_{1i} = 0\ and\ \tau_{1i} = 0$ the rejection of Ho infers that both Gross capital formation and energy consumption (renewable and nonrenewable) affect GDP in the short-run (H1:$\gamma_{1i} \neq 0, \delta_{1i} \neq 0, \varphi_{1i} \neq 0\ and\ \tau_{1i} \neq 0$).

3.6.2.2 Hypothesis in the long run

As previously stated, vector error correction terms can cause null hypothesis in the long run; the indications of Ho are:β_{11} implies that the long-run equilibrium deviation to lnY_t be not causal. $\beta_{11} \neq 0$ is the alternative hypothesis.

4. EMPIRICAL RESULTS AND DISCUSSIONS

4.1 Matrix of correlations

Table 1. Correlations' matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lnrealgdp_diff	1.000						
(2) lnkapital_diff	0.956	1.000					
(3) lntlf_diff	0.448	0.336	1.000				
(4) lntfec_diff	0.464	0.535	-0.039	1.000			
(5) lnrecn_diff	0.474	0.547	-0.048	0.997	1.000		
(6) lnnonrecn_diff	0.045	0.031	0.122	0.009	-0.059	1.000	
(7) infl	-0.221	-0.090	-0.521	0.267	0.286	-0.274	1.000

From the table1 reveals the correlation among the variables, which indicates that only the first difference of the real domestic production is highly correlated with the capital formation with the correlation coefficient of 0.95.

4.1 Descriptive statistics

Table2. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Realgross domestic production	4.963e+09	2.855e+09	1.303e+09	1.138e+10
Gross capital formation	9.759e+08	9.055e+08	50725256	3.273e+09
Total labor force	4372137.8	1064395.4	2939305	6354567
Inflation rate	7.572	5.402	-2.41	19.64
Total final energy consumption	61227.913	16103.734	29724.34	82491.078
Renewable energy consumption	54163.521	15420.285	23345.189	73975.641
Non-renewable energy consumption	7064.392	1161.709	5675.51	10614.92

Table2 the descriptive statistical analysis of all the endogenous variables used in this study are indicated above for the entire analysis, where the real GDP is measured in 2010 US dollars, gross capital formation is measured in 2010 US dollars, renewable energy consumption is measured in Terajoules (TJ), total final energy consumption is measured in Terajoules, (TJ), non-renewable energy consumption is measured in Terajoules, (TJ) total labor force is measured as the number of the populationwho are able to do a work while the inflation rate is measure in percentage

Over the sample period in Rwanda, the mean value of the real gross domestic product is the US $ 4.96 billion. The real gross domestic production varies between US$ 1.3billion and 11.4 billion. The degree of variability is also witnessed by the standard deviation of US$ 2.8 billion indicating that the data are scattered away from the mean value.

The renewable energy consumption has a mean value of 54,163.521 TJ with the variation range between 23,345.189 TJ and 73,975.641 TJ where the degree of variability of renewable energy consumption is revealed by the standard deviation of 15,420.285 TJ and this indicates that the data are scattered away from the mean value of the renewable energy consumption while non-renewable energy consumption has the mean value of 7,064.392 TJ with the range of variation between 5,675.51 TJ and 10614.92 TJ where the degree of variability is indicated by the standard deviation of 1,161.709 TJ.

The total labor force has its mean value at 4,372,138 people and the variation range of the total labor force is between 2,939,305 and 6,354,567 people while the degree of variability for the total labor force is shown by its standard deviation of 1,064,395.4 people and this indicates that the data for the total labor force have deviated away from its mean value.

From table 2 above the description of statistics reports that the gross capital formation has its mean value at the US $ 976 million with the variation between US$ 50,725,256 and the US $3.3 billion while is the standard deviation of US$ 905.5 million indicate the degree of its variability and this reveal that the gross capital formation data are spread away from its mean value.

4.2 Empirical results

4.2.1 Stationarity tests

To avoid the problem of false regression, the stationarity property of all variables is evaluated. The augmented Dickey and Fuller (1981) (ADF) test, the Phillips and Perron (1988) (PP) test, and the enhanced Dickey and Fuller (1981) (ADF) test are used to guarantee that the estimated findings avoid the problem of misleading inferences. According to the ADF, PP tests, only the first difference of all the variables is stationary at the I (1) level, as shown in the estimated findings in the figure below:

Table3: First difference Augmented dickey fuller test (ADF) and pperron unit root test

variable	*dfuller_statistic*	*dfuller_cvalue*	*dfuller_pvalue*	*dfuller_lags*	*pperron_statistic*	*pperron_rho*	*pperron_pvalue*	*pperron_lags*
lnrealgdp_diff	-5.545	-2.992	0.000	0.000	-5.585	-28.210	0.000	3
lnkapital_diff	-7.315	-2.992	0.000	0.000	-7.510	-36.035	0.000	3
lntlf_diff	-1.716	-2.992	0.423	0.000	-1.988	-6.329	0.292	3
lntfec_diff	-5.820	-2.992	0.000	0.000	-5.799	-32.989	0.000	3
lnrecn_diff	-5.851	-2.992	0.000	0.000	-5.832	-32.937	0.000	3
lnnonrecn_diff	-5.934	-2.992	0.000	0.000	-5.886	-32.899	0.000	3
	-3.631	-2.989	0.005	0.000	-3.704	-20.432	0.004	3

From the table above reporting the unit root test or stationarity combining the dickey fuller and pperron tests shows that the data is stationary or satisfy the stationarity condition as the p-values on bothtests are significant at first difference

4.2.2 Determination of optimal lag length

The determination of the optimal lag duration is critical in the VEC model. The number of earlier periods in which economic growth has influenced current economic growth can be determined for this purpose. The VEC model determines the best lag lengths automatically, starting with a lag length of 4. The lag lengths were calculated and the results are given in the diagram below. According to the results in the graph below, the model's best lag duration is 4 based on all three criteria, AIC, SBIC, and HQIC. Because all of the variables are stationary at I (1), AIC determines that VEC (4) is the best VEC model for the data, resulting in p = 4 in equation (2).

Selection-order criteria

Sample: 2458q3 - 2464q4 Number of obs = 26

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	133.525				1.4e-13	-9.73267	-9.63514	-9.39396
1	334.525	402	49	0.000	1.4e-18	-21.425	-20.6447	-18.7153
2	457.876	246.7	49	0.000	1.2e-20	-27.1443	-25.6812	-22.0635
3	2019.38	3123	49	0.000	2.9e-69*	-143.491	-141.345	-136.039
4	4908.41	5778.1*	49	0.000	.	-363.57*	-361.034*	-354.763*

Endogenous: lnrealgdp lnkapital lntlf lntfec lnrecn lnnonrecn infl

Exogenous: _cons

4.2.3 Cointegration test

According to the johansen's (1995) examination of the cointegration property for time series data, there may be long-run cointegration among the variables. The table below shows that at the 5% significance level, the trace statistic of 44.1423 is less than the critical value of 47.21 for the highest rank of three cointegration equations. The results of the cointegration test show that there exists long-runcointegration for the seven variables, *lnrealgdp lnkapital lntlf lntfec lnrecn lnnonrecn and infl*. Since the cointegration test indicates that there exists a long-run relationship among the variables at the maximum rank of 3 therefore, equation (3.7) should beestimated using the error correction model.

Table4: Johansen tests for cointegration

Trend: constant Number of obs = 28

Sample: 2458q1 - 2464q4 Lags = 2

Maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	56	288.1263	.	253.6399	124.24
1	69	331.38777	0.95450	167.1170	94.15
2	80	368.0137	0.92692	93.8651	68.52
3	89	392.87509	0.83065	44.1423*	47.21
4	96	404.96053	0.57821	19.9715	29.68
5	101	411.21156	0.36014	7.4694	15.41
6	104	414.83119	0.22783	0.2301	3.76
7	105	414.94625	0.00819		

Source. the results From Stata

4.3 Impulse Response Function analysis

Here we have impulse variable and response variables where we analyzed the response to the economic growth indicating variables like real gross domestic output, capital formation, and total labor force due to the standard deviation shock or innovation that occurred to the energy consumption through which we have chosen 1 step due to constant variation of the gradient.

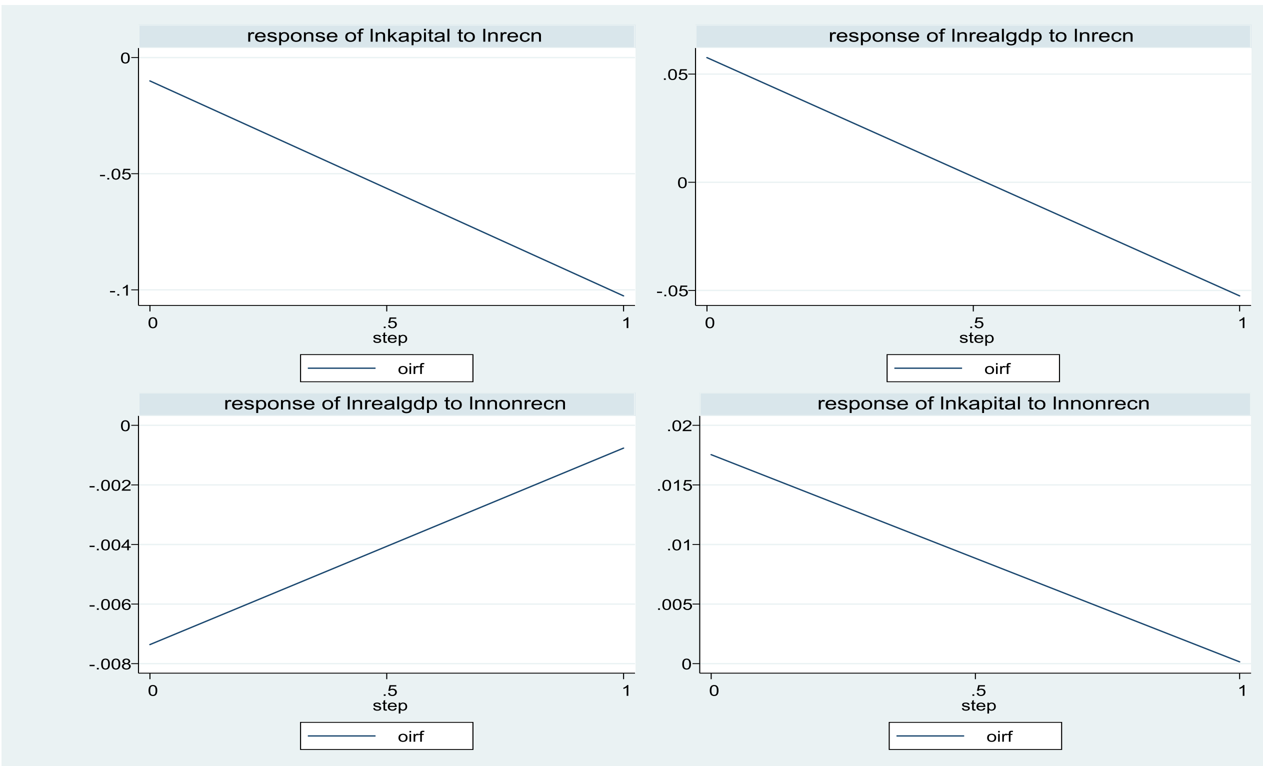


Figure 1. Graph by irfname, impulse variables (lnrecn and lnnonrecn), and response variables (lnkapital and lnrealgdp)

From figure 1 reporting that a one standard deviation shock or innovation occurred to the renewable energy consumption leads to the decrease of the capital formation and the decline continues at a constant gradient leading to the negative impact of the renewable energy consumption on capital formation both in short-run and long-run all in the same negative region. A unit standard deviation to the renewable energy consumption associated with the decline in the real gross domestic output and this declination continues at constant slope leading to the negative impact on the real gross domestic output in the positive region for short-run period and negative impact on the real gross domestic output in the negative region during the long-run period and this accords with the fact that most of renewable energy resources initially require the government intervention through incentives and subsidies through minimizing the cost of energy due to sustainable development of the energy sector and then the gross output of the nation decrease due to the renewable energy consumption.

The shock to the nonrenewable energy consumption is associated with the increase in the real gross domestic output where this inclination continues at a constant gradient leading to the positive impact of the innovation to the nonrenewable energy consumption on the real GDP output both in the period of the short and long term in the same negative region and this accords the fact that since most of the nonrenewable energy consumption takes place in the industrial sector and industrial sector plays a crucial role in the real gross domestic production hence the nonrenewable energy consumption has a positive impact on the real gross domestic product of the country and then the economic growth and this accord what found that energy consumption and economic growth goes into one way as shown by (Kraft,J. , Kraft, A.) Relationship between energy and GNP (Energy Dev 1978,3,401-403).

The standard deviation shock to the nonrenewable energy consumption is leading to the decrease of the capital formation where this decline continues to a constant slope leading to the negative impact of nonrenewable energy consumption on the capital formation and this goes in line with the fact that currently, more investment is being out in the renewable and nonpolluting energy sources towards the clean energy sector policy for reducing the nonrenewable energy consumption towards the full energy consumption and the capital formation inversely proportionated with nonrenewable energy consumption hence the economic growth.

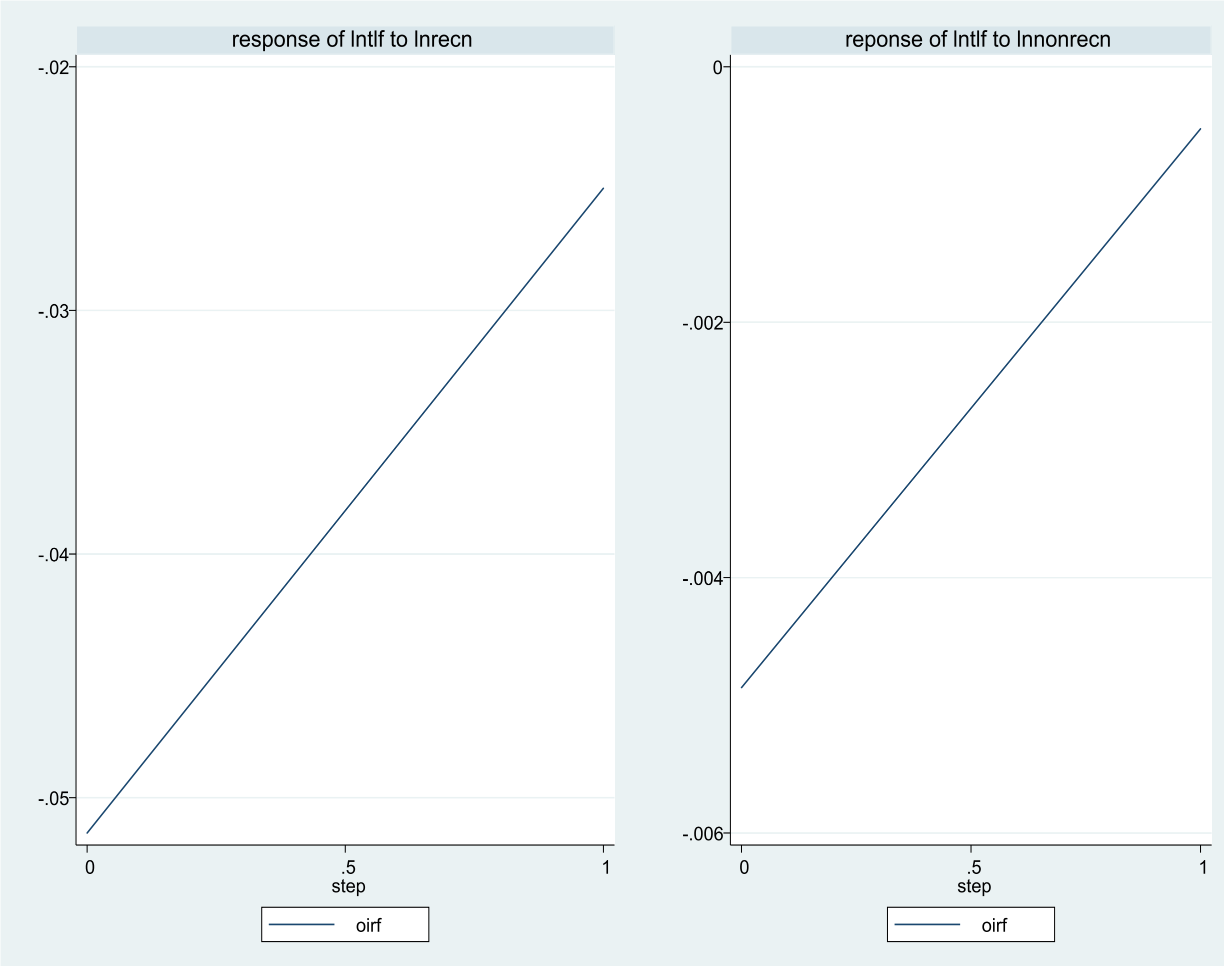


Figure 2.Graph by irfname, impulse variables (lnrecn, lnnonrecn), and response variable (lntlf)

From figure2 showed that a unit standard deviation shock to the renewable energy consumption is associated with the increase in the total labor force in the country where this inclination continues at the constant gradient leading to the positive impact of the renewable energy consumption on the total labor force both in short-run and long-run period in the same negative region and this goes in line with the circumstance that when the renewable energy consumption increase this leads to rise in the job creation through using and consumption of the renewable energy throughs from off-grid solution and mini-grid services for improving the energy access, services provision and manufacturing and business creation at a different level and this leads to increase in the employment hence the total labor force increased in the country.

A unit standard deviation shock or innovation takes lace to the nonrenewable energy consumption is associated with the increase in the total labor force in the country where this inclination continues at a constant slope leading to the positive impact of the nonrenewable energy consumption on the total labor force both in short-run and long-run in the same negative region and this goes in line with the fact that since the most nonrenewable energy consumption is occupied by the industrial sector and these industries need labor due to the manufacturing and processing activities and different practices requiring the labor force increase and this leads to the economic growth resulting from the industries consuming the nonrenewable energy and hiring the labor in their various processes and thus directly contribute to the real gross domestic product and hence the economic growth

4.4 Vector Error Correction Model

The estimation results of VECM model are shown in the table below for the long-run causality relationship between real GDP, capital formation, final energy consumption, renewable energy consumption, non-renewable energy consumption, total labor force and inflation variables.

Table5: Estimation results from Vector Error CorrectionModel (VECM)

VARIABLES	(1) D_lnrealgdp	(2) D_lnkapital	(3) D_lntlf	(4) D_lntfec	(5) D_lnrecn	(6) D_lnnonrecn
L._ce1	0.907	3.502	0.026	0.194	0.634	-2.751
	(1.317)	(3.804)	(0.041)	(0.453)	(0.692)	(1.992)
L._ce2	-0.292	-2.591	-0.009	-0.237	-0.528	1.663
	(1.416)	(4.090)	(0.044)	(0.487)	(0.744)	(2.142)
L._ce3	1.628	9.032	0.042	0.799	1.748	-5.410
	(3.919)	(11.321)	(0.122)	(1.349)	(2.059)	(5.928)
LD. lnrealgdp	-1.757	-2.865	-0.036	0.214	0.112	0.567
	(1.854)	(5.357)	(0.058)	(0.638)	(0.974)	(2.805)
L2D.lnrealgdp	-0.428	1.079	-0.032	0.448	0.375	1.214
	(1.786)	(5.159)	(0.056)	(0.615)	(0.938)	(2.702)
L3D.lnrealgdp	-1.501*	-3.893*	-0.043*	0.388	0.204	1.660
	(0.795)	(2.296)	(0.025)	(0.274)	(0.418)	(1.202)
LD. lnkapital	0.215	1.302	0.011	-0.098	0.112	-1.518
	(0.661)	(1.910)	(0.021)	(0.228)	(0.347)	(1.000)
L2D.lnkapital	-0.218	-0.419	0.006	-0.024	0.158	-1.406*
	(0.535)	(1.547)	(0.017)	(0.184)	(0.281)	(0.810)
L3D.lnkapital	0.507	1.674	0.012	0.088	0.232	-0.762
	(0.653)	(1.887)	(0.020)	(0.225)	(0.343)	(0.988)
LD. lntlf	5.279	-16.808	1.200***	11.388**	17.936***	-35.982*
	(13.117)	(37.891)	(0.409)	(4.515)	(6.891)	(19.842)
L2D.lntlf	34.639	122.885	0.251	-9.669	-10.982	5.993
	(31.249)	(90.269)	(0.975)	(10.757)	(16.417)	(47.270)

L3D.lntlf	-21.333	-82.232	-0.199	-9.060	-7.852	-23.012
	(21.373)	(61.740)	(0.667)	(7.357)	(11.229)	(32.331)
LD. lntfec	-3.891	-27.334	-0.897	-4.966	-18.376	84.682
	(59.476)	(171.808)	(1.856)	(20.474)	(31.247)	(89.969)
L2D.lntfec	-15.278	-37.913	-0.602	-0.230	-3.537	16.125
	(22.297)	(64.411)	(0.696)	(7.676)	(11.714)	(33.729)
L3D.lntfec	5.417	28.707	-0.395	8.085	8.850	7.223
	(19.203)	(55.473)	(0.599)	(6.611)	(10.089)	(29.049)
LD. lnrecn	4.393	25.370	0.824	3.411	15.636	-78.515
	(52.500)	(151.656)	(1.638)	(18.073)	(27.581)	(79.416)
L2D.lnrecn	13.902	33.744	0.570	-0.269	2.947	-16.870
	(19.704)	(56.919)	(0.615)	(6.783)	(10.352)	(29.806)
L3D.lnrecn	-4.064	-23.232	0.368	-7.376	-7.954	-7.235
	(16.604)	(47.965)	(0.518)	(5.716)	(8.723)	(25.118)
LD. lnnonrecn	0.789	4.622	0.110	0.777	2.473	-10.578
	(7.156)	(20.673)	(0.223)	(2.464)	(3.760)	(10.826)
L2D.lnnonrecn	2.316	6.750	0.081	0.257	0.816	-2.705
	(3.262)	(9.424)	(0.102)	(1.123)	(1.714)	(4.935)
L3D.lnnonrecn	-0.283	-1.813	0.053	-0.862	-0.800	-1.745
	(1.600)	(4.623)	(0.050)	(0.551)	(0.841)	(2.421)
Constant	0.008	-0.012	0.011**	0.027	0.030	-0.003
	(0.148)	(0.426)	(0.005)	(0.051)	(0.078)	(0.223)
Observations	26	26	26	26	26	26

Notes Titles Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

From table 5 reports the estimation results for the full time series vector error correction model with endogenous variables (four optimal lags for each of the variables real gross domestic production (realgdp), inflation rate (inf), renewable energy consumption (recn), nonrenewable energy consumption (nonrec), total labor force (tlf), total final energy consumption (tfec) and gross capital formation(kapital).

From the table5 above reported that the third lag of in real gross domestic production has a negative effect on the change in capital formation significant at 10 percent and this shows how the capital investments in the non-renewable which are most polluting energy sources through improving the contribution of renewable energy in the full access. Interestingly, third lag ofreal gross domestic production has a negative influence on thetotal labor force which is significant to 10 percent. From table5 results shows that the first lag of total labor force has a positive effect on the change in total final energy consumption and this is significant at 5 percent and this goes in line with the fact that that the final energy consumption leads to the increased job creation and then employment increase resulting to increased labor force while this has a positive effect on thetotal renewable energy consumption and this is significant at 1 percent.

From table5 above discovered that only the third lag ofin real gross domestic product has a significant negative effect and significant at 10 percent. Surprisingly the second lag ofcapital formation has a negative influence on thenon-renewable energy consumption which is significant at 10 percent and the first lag of in total labor force has a negative influence on thenon-renewable energy consumption which is significant at 10 percent while the first lag of total labor force has a positive significant influence on the renewable energy consumption and this goes in line with the circumstance that the renewable energy consumption leads to the increased job creation and then employment increase resulting to increased labor force.

5 CONCLUSION AND RECOMMENDATIONS

Although the economic growth and the energy consumption in any economic sector have been extensively studied, the impacts of energy consumption on the real gross domestic production have received less attention, especially in Africa. In this study we have analyzed the causal relationship between the energy consumption and economic growth for Rwanda measured by real gross domestic product in this study, by using vector error correctionmodel analysis, The empirical investigation for 1990-2019 periods, According to the ordinary least squares estimation with the vector autoregressive model, there is a positive relationship between energy consumption and real gross domestic, which measures economic growth.

The study's conclusion is that for an electricity-deficient country like Rwanda, where nonrenewable energy sources play a large role in the electricity sector, and based on the findings, the increased nonrenewable energy consumption leads to the decline of the real gross domestic production hence slow economic growth and this confirms that with either energy consumption or real gross domestic production as a dependent variable since there exist the long-run relationship as shown by Constantini and martini (2010), To improve the contribution of the energy sources to total energy consumption, planning and investment in infrastructure development are required.

More significantly, Rwanda has already demonstrated an impressive ability to develop, deploy, replicate and scale up innovative, market-based approaches to energy consumption through improving its contribution to full energy access. The country has an excellent basis for further energy policy innovation and market creation, including the strong community of non-governmental organizations, research institutes, and think tanks active in energy access. the governments should encourage the cooperation projects aiming at reduction of pollution level through enhancements of energy consumption.

The relevant government must take the actual situation of the investment and gross capital formation in the energy sector through improving the energy consumption, rationally to determine carbon emission reduction targets for hindering the increased carbon taxes and charges due to the Kyoto Protocol and Paris agreement and this will hinder the economic growth. The investments practices in renewable energy could permit countries to avoid a situation of energy infrastructure enclosed into carbon-intensive development models and vulnerable to climate hence hindering sustainable economic growth. So, Rwanda should encourage the exploitation of renewable energy as well as the adoption of clean technologies using renewable energy in the production processes and this could help stimulate economic growth because of the great potential of renewable energy sources in the country. However, economic growth causes environmental degradation in a given economic sector due to nonrenewable energy consumption, whereas improved renewable energy consumption and gross capital formation inflows, in particular, result in lower carbon emissions, as a serious shift towards the developed renewable energy consumption and the increased foreign direct investment in energy sector inwards is recommended to improve environmental quality through energy consumption and attainment of sustainable economic growth in Rwanda.

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