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The African Center of Excellence in Energy for sustainable development (ACE-ESD)

"Determinants of Carbon dioxide emission in Rwanda: Evidence from renewable and non-renewable energy"

This thesis submitted to the African Center of Excellent in Energy for Sustainable Development in partial fulfillment of the requirement for the degree of MASTERS OF SCIENCE IN ENERGY ECONOMICS.

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DECLARATION

I, **Jean Claude KAYANDA** approved that this work is my original project, and has not been published or presented by others university or university of Rwanda .All document or material that was used in this project have fully acknowledged.

My names: **Jean Claude KAYANDA** My Signature

SUBMISSION

The date of submission **05th November, 2021**

This project submitted to the examination with my approval as a university advisor.

Dr. KABANDA Richard

Thesis supervisor

Advisor signature

DEDICATION

My beloved wife MUTUYIMANA Francoise;

My brothers and sisters;

All UR/ACE-ESD Community;

My classmate in program of Energy Economics;

Anyone else who is not appearing in this list but whose role is recognized.

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May God bless you abundantly

Mr. Jean Claude KAYANDA

LIST OF ABBREVIATIONS, SYMBOLS AND ACRONYMS

ACE-ESD: African Center of Excellent in Energy for Sustainable Development

ARDL: Autoregressive Distribution Lag

CO2: Carbon Dioxide Emission

DOLS: Dynamic Ordinary least Squares

EKC: Environmental Kuznets Curve

FMOLS: Fully Modified Ordinary Least Squares

GDP: Gross Domestic Product

GHG: Green House Gas

GoR: Government of Rwanda

OECD: Organization for economic co-operation and development

OLS: Ordinary Least Squares

PHH: Pollution Haven Hypothesis

REMA: Rwanda Environmental management Authority

SSA: Sub-Saharan African

TJ: Terajoules

UR: University of Rwanda

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Abstract

Environmental deterioration is a challenge in developing countries. Any use of nonrenewable energy demand for economics progress cause the environment damage, however the consequences of environmental degradation cannot be overlooked. The major goal of this research is to examine the effect of renewable and nonrenewable energy consumption on carbon dioxide emission using quarterly data from 1990 - 2018 in Rwanda. We employ the autoregressive distributed lag (ARDL) bounds test procedure for co-integration, and the estimated ARDL findings demonstrate that nonrenewable energy consumption increases the carbon dioxide emission in Rwanda in short run and long-run. On the contrary, research indicates that renewable has a negative influence on the environmental degradation, the results support the presence of Environmental Kuznets Curve Hypothesis; however, the highest gross domestic product value in logarithmic scale in our data is smaller than the expected turning point. Based on the estimated results, policymakers in Rwanda may implement and encourage renewable source of energy to help satisfy rising energy demand by replacing old traditional sources of energy such as wood and fuel by renewable sources of energy and to attract foreign investors. The renewable energy sources can be used multiple times so that to reduce the carbon dioxide emission and to ensuring Rwanda’s long-term economic development.

CHAPTER I: INTRODUCTION

1.1. Background

Climate change has evolved into an important problem that has attracted the attention of scientists and policymakers in past few decades (Asumadu-Sarkodie & Owusu, 2017). Then there is the fact that climate change is a global issue that necessitates global solutions. Greenhouse gas emissions, such as carbon dioxide, are the main cause of the environment degradation. In the worldwide carbon dioxide emissions have climbed where it was 1.4 parts per millions in 1995 to 2 parts in 2017 per year over (Asumadu-Sarkodie & Owusu, 2017). The Carbon dioxide emission can affect the change of climate ,this become a serious nationally and internationally socioeconomic challenge due to air pollution and carbon emissions pollutants into the atmosphere.

The majority of researchers concentrated not only on estimating carbon dioxide emissions to combat climate change, but also on energy consumption, which is the primary source of carbon dioxide emissions (Uwamahoro & Niyigena, 2019). The combustion of non-renewable is thought to be the main source of increase of CO2 emission in the atmosphere, which has been recorded in numerous sites across the world (Rotty, 2015). However, the combustion of non-renewable energy consumptions now accounts for around 80% of worldwide CO2 emissions (Schmalensee et al., 2016).

It is well known that when congestion grows, CO2 emissions and fossil fuel consumption growth in the same way (Barth & Boriboonsomsin, 2008). Similarly, among 132 countries, if one country's population density is 10% increases than other countries, and all other variables remain the same, the country's per capita CO2 emissions will be 7.69% higher. As a result, those countries' trade dependency rises by 10%, their per capita CO2 emissions rise by 2.05 percent, and their export of goods and services rises by 3.01 percent (Liao & Cao, 2013).

Thus, the Economic growth driven by energy consumption and international trade has contributed in increased levels of carbon dioxide. These emissions contribute to climate change, which has a negative impact on human health and has significant socioeconomic consequences, as well as a reduction in economic growth. As a result, the majority of governments, including European Union countries, have signed the Kyoto Protocol, which includes binding promises to reduce carbon dioxide emissions (Dogan & Seker, 2016).

This region has set long-term growth goals of reducing carbon dioxide emissions by 80% between 1990 and 2050, with 1.44 global hectares (gha) of environmental impact development per capita and an increase in Human development index. The Carbon dioxide emissions have increased for the countries of Sub-Saharan in Africa (SSA) countries due to economic development, population growth, and other factors (Hamilton & Kelly, 2017). Naturally, energy use will increase the level of emissions. Using both renewable and non-renewable energy has resulted in an increase in carbon dioxide emissions which contributes more than 90% and manufacturing and transportation with the share of the carbon dioxide emissions by 24% and 20% respectively to greenhouse emissions in South Africa (Wirtschaft, 2012).

Not only for South Africa and for 28 countries of African have problem of carbon dioxide emission. They find that in short run one percent increase in nonrenewable energy use lead to be increase the carbon dioxide emission by 1.07 percent and in long run one percent increase in nonrenewable consumption cause the increase of carbon dioxide emission by 1.9 percent while the GDP leads to increases 1.3 percent on the carbon dioxide emission (Adams & Nsiah, 2019).

Furthermore, (Dogan & Seker, 2016a) discover that a one percent added on the renewable source of energy and international trade reduces the carbon dioxide emission by 0.03 and 0.06 percent respectively, but one percent rise in non-renewable energy adds to 0.44 percent environmental damage. These figures show the causes of carbon dioxide emissions in Africa, although there is much literature on the factors that influence carbon dioxide emissions in other countries.

A country of Rwanda was progressively experienced the effects of global climate change, such as flooding, which results in disasters such as landslides, which cost lives and resources, and droughts, which have a negative impact on agricultural output and health of people (Vision, 2020). Since 1970, the country's average temperature has risen by 1.4°C, exceeding the global average of 0.27°C, and by the 2050s, it is expected to rise by up to 2.5° C (REMA, 2011).

On another hand, Rwanda's economy is strongly reliant on its environment and natural resources, and the access, use, and management of these resources is critical to the livelihoods of rural and increasingly urban residents. Development operations in a crucial sector of the energy sector can cause significant environmental deterioration, which can stifle economic growth if they are not managed properly (REMA Report, 2021). Therefore, Different econometric approaches were used to identify the CO2 emission determinant that played a larger role in the causality of environmental pollution in various countries. In the case of Rwanda, however, there is a scarcity of literature. This tempts to make a research for contribution of renewable and nonrenewable energy consumption on carbon dioxide emission in Rwanda.

1.2. Statement of the Problem

The share of Rwanda to the change of climate in the form of greenhouse gas emission is negligible. Nevertheless, the contribution from agriculture, deforestation and land use expect to growth emission as economic development increase and energy consumption. Those are large enough within Rwanda’s carbon dioxide emission footprint to need conservation response(GoR, 2020). Furthermore, in Sub-Saharan countries the carbon dioxide emission was 378.4Mt in 1980 and it rise to 822.3Mt in 2014 then this cause an increase of 117.3% of carbon dioxide emission in sub-Saharan countries (Lin & Agyeman, 2020). whereas the Carbon dioxide emissions of Rwanda are on the rise, with contributions of 37.35 percent, 42.50 percent, and 46.16 percent in 2006, 20012, and 2015, respectively (REMA, 2018).

The GHG emissions in Rwanda have risen steadily over the years, in 2003 was 2,896.34Gg and rise to 5,793.45 in 2006 and this is expect to continuous to rise as the economy of the country increase. Rwanda's emissions rose by 50% by 2020, as referred to Low-carbon path and National Energy published by Rapid assessment, (Byamukama, 2018). Thus, the gas per gas analysis reveals that carbon dioxide is the primary source of emissions, accounting for 94% of total emissions over a ten-year period (REMA, 2018).

Moreover, according to the third National Communication (2019), Rwanda will most likely become a carbon emitter in 2022 if the recommended mitigation option is not implemented. In fact, between 2006 and 2015, estimated carbon dioxide emission from the energy sector increased at the rate of 4.2 percent per year. Obviously, GHG emissions increased in lockstep with rises in both fuel consumption and GDP; one percent in increase of GDP per capita will decrease carbon dioxide emissions by 1.45%, in the long run. Based on the research of (Nutakor et al., 2020), it is expected that the carbon dioxide emission in Rwanda will be double from 2015 to 2030 by growing from 5.3 to 12.1 million tons of equivalent of carbon dioxide emission due to increase of using energy of fossil fuel in businesses and road transport. This problem of climate change is associated with energy demand on fossil fuel in Rwanda (Asumadu-Sarkodie & Owusu, 2017).

With considering the information as delivered from different researchers and scholars about the carbon dioxide's impacts on the climate change issues and energy use. those researchers were used the annually data but, this study will assess the relationship between both Renewable and nonrenewable energy use and the carbon dioxide emission by using quarterly data of Rwanda the test of the EKC hypothesis.

1.3. Objectives of the study

In this section, there are general objective and specific objective. These are presented below:

1.3.1. General Objective

The main of objective of this project is to examine the determinants of carbon dioxide emission for Rwanda.

1.3.2. The Specific Objective

Those are the specific objectives of this research project:

a) To examine the influence of renewable energy on the CO2
b) To investigate the effect of nonrenewable energy use on the carbon dioxide
c) To examine whether or not the inverted U-shaped EKC hypothesis holds in Rwanda

1.3.3. Research questions

a) To what extent does renewable source of energy use affect CO2 in Rwanda?
b) What are the effects of the nonrenewable energy use play out to CO2 in Rwanda?
c) What are the behaviors of the Environmental Kuznets Curve hypothesis in Rwanda?

1.4. Scope of the study

This study will focuses on investigation of causal relationship between both renewable and nonrenewable energy on carbon dioxide emission .This study need to see the impact of these variable on carbon dioxide emission as well as the verification of U-shape of Kuznets curve. The quarterly data from 1990 to 2018, which observed at latest version of world development indicator for case of Rwanda, will be used.

1.5. Expected Outcomes and Significance of the Study

1.5.1. Expected Outcome of the Study

The prediction outcome of this study is a negative or positive effects between the CO2 and its determinant in Rwanda as well as testing the U-shaped of environment Kuznets curve hypothesis.

i. This research is to determine the influence of renewable and nonrenewable energy use on carbon emissions in Rwanda and we believe that Rwanda's energy usage has played a substantial role in the country's carbon emissions.
ii. The test of inverted U-shaped of EKC indicates that we have a problem of the carbon dioxide emission increases as economic growth rise; hence, this encourages the country to make a strong climate change mitigation policies in different sectors of economy.

1.6. Significance of the Study

The purpose of this project is to look at the factors that influence CO2 levels Rwanda's emissions from 1990 to 2018.

a) Due to the obvious availability of data, the sample size for this study is larger than in the previous studies As a result, we anticipate receiving an additional contribution to the recent literature.
b) The study should therefore consider population growth as a new determinant of carbon dioxide emissions, which has not been used in previous research in order to avoid biased estimate.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction**:**

In this chapter of literature, reviews will explain the major idea, conduct the theoretical framework and empirical narratives about the factors that influence carbon dioxide emissions in Rwanda.

2.2. Definition of key concept.

a) **The Environment Kuznets Curve:** This is an hypothesis model, which stated that environmental degradation increases with economic development until to the maximum point , after which economic progress cause the environment benefit and this make a U-shape relationship among the economic development and environment deterioration by (Destek & Sarkodie, 2019).

b) **The Gross Domestic Product:** refer as the total value of all goods and services produced with in the country in specific period of time.

c) **Renewable energy consumption:** according to (Herzog et al., 2001) a renewable is an energy that comes from a natural sources of energy and can be generated naturally for example sunrise like Rwamagana solar power plant and wind , wives.

d) **Nonrenewable energy consumption:** Nonrenewable energy is obtained from resources that will decrease over time or will not be replenished for thousands if not millions, of years, according to (Huesemann, 2003). The most popular nonrenewable energy source is fossil fuels.

e) **Carbon dioxide emission (CO2)** refer as the combination of gases of colarless, odorless created by carbon decomposition and living organism respiration that categorized as a greenhouse gases emission(Load & Plants, 2018).

2.3. Theoretical literature review

2.3.1. Neo-classical (neutrality) hypothesis literature review

The classical theory evolved into a distinct theory, neoclassicism, while retaining the core aspects of the classics was also influenced by Keynesian theory and changes in the economic sphere. The classical general equilibrium model, which describes the economy by aggregating the behaviors displayed by variables to another, is based on this principle (Caraman, 2015).

Due to another factors to growth based on the energy the Neo-classical (neutrality) hypothesis (Menegaki et al., 2011) argued that the consumption of energy does not have a relationship with the carbon dioxide emission (Pata, 2018). However, according to the non-neutrality hypothesis state that the energy is basic requirement of productions and this cause the carbon dioxide emission that can reduce the economic growth in the country.

Furthermore, (Tugcu et al., 2012) claimed that neutrality hypothesis has three theoretical models: (i) the direction of energy consumption to carbon dioxide emission is supported for unidirectional causality and is call growth hypothesis (Halicioglu, 2009). (ii) The conservation hypothesis proposes that the direction from carbon dioxide emission to energy consumption tend to be unidirectional causality (Huang et al., 2007); (iii) whereas the feedback hypothesis proposes that between energy consumption and CO2 , there is a bidirectional causality (Li et al., 2017).

2.3.2. Environmental Kuznets Curve (EKC) hypothesis

In 1990s, the EKC hypothesis has been the most popular explanation for the relation between economic development and environment deterioration. According to the EKC hypothesis, economic activity and environmental deterioration have inverted shaped relation. In the beginning stage the pollution and deterioration are in the same way with the economic growth but after to reach at turning point, the economic growth contribute to environment benefit for developed countries due to advanced technology (Grossman & Krueger, 1991). The validated relationship between the economic growth and environmental degradation is described in the figure below:

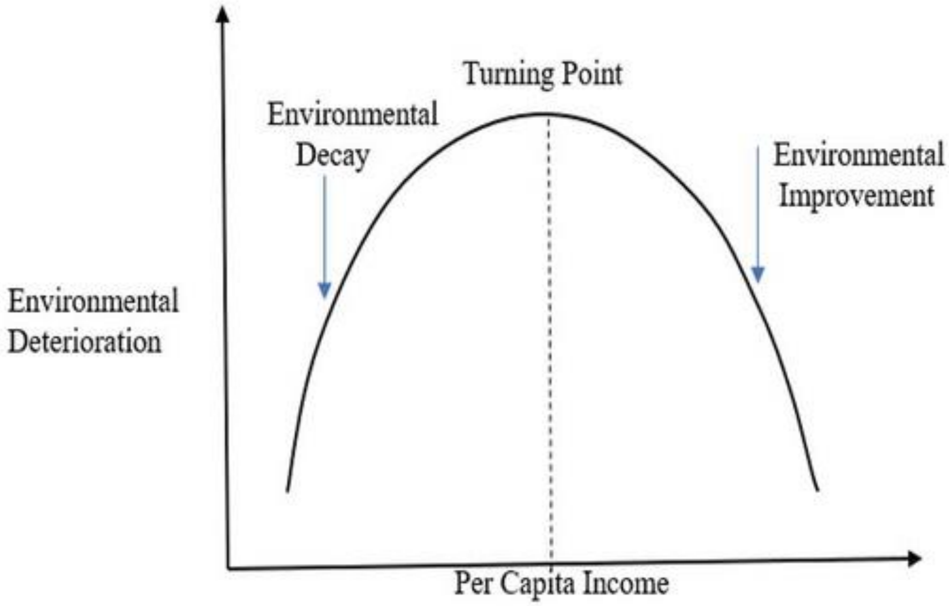

Figure 1: Environmental Kuznets curve

In fig. 1, above depicts the Environment Kuznets curve, which shows that as GDP per capita rises, the environment degrades until it reaches a turning point, at which point the environment improves cause a lower carbon dioxide emissions. Therefore, various macroeconomic models have suggested that, like capital and labor, energy use as a factor of production contributes to GDP growth however, Energy consumption, on the other hand, makes a significant contribution to GDP per capita (Zaheer Abbas, 2020).

In addition , the energy production is most important in economic development which means that a reduction of energy production affect economic development as well as it can cause economic crisis based on the growth hypothesis (Isik et al., 2018). According to this, investments in the energy sector have an impact on climate change. Furthermore, if CO2 is released during the manufacturing process, economic growth could follow CO2 emissions rather than the other way around (Soytas et al., 2010).

2.3.3. Pollution haven hypothesis (PHH)

This theory of pollution haven hypothesis describe the theory between the environment degradation and trade where the developed countries have stronger regulation for trade whereas in developing countries there a weak regulation , this promote the advantage on environment deterioration . As a result, polluting businesses relocate their operations from industrialized to developing countries, transforming poor countries into pollution havens. Since firms seek to leverage such competitive advantages, like low salaries and energy costs, the lack of environmental regulations etc.

The pollution haven hypothesis (PHH) arises when trade barriers are reduced, resulting in increased trade and associated emissions. But, there others theory that state that trade theory suggest that there are many others factor that can support the pollution haven hypothesis because the pollution regulation affect the trade in flows (Agreement, 2004). The pollution haven hypothesis indicates that environmental regulations influence exports, but it is also possible that regulations influence exports. If trade raises income and environmental quality becomes a standard good, lawmakers may demand stringent environmental restrictions. Alternatively, greater pollution from trade may raise local demand for stricter environmental restrictions.

2.4. Empirical literature review

This area of empirical study is going to be described based on tree sections where the first one describes the contributions of various authors who conserved the environmental Kuznets curve hypothesis in their analysis. The second section is imperial related with impact of trade on carbon dioxide emission and the third section is empirical of renewable and nonrenewable energy as well as the conceptual framework and conclusion.

2.5.1. Literature of Environment Kuznets curve hypothesis

Several studies try to work on the environment Kuznets curve framework but most of them they did not test the present of EKC hypothesis. For instance of authors that investigate the presence of the environmental Kuznets curve. (Yavuz, 2014) and (Seker et al., 2015), (Jebli et al., 2016) confirm the Environment Kuznets curve hypothesis's applicability for Turkey. Thus many researchers has been examined a existence of EKC hypothesis, another example, (Dogan & Seker, 2016) investigate the impact of GDP , renewable and nonrenewable energy consumption , trade and carbon dioxide emission in the top countries by referring to the EKC model. This research of (Dogan & Seker, 2016) indicate that the increases of using the renewable energy consumption and trade lead to reduce the carbon dioxide emission however using nonrenewable energy consumption causes the increase of carbon dioxide emission. Furthermore, the existences of Environmental Kuznets curve hypothesis hold in the top countries of renewable energy use. In the same way (Chen, Wang, et al., 2019) have done a study of relationship between the carabon dioxide emission, nonrenewable and renewable energy , trade and gross domestic product in China by using the technical of Autoregressive distribution lag model from 1980 to 2014. The results of this study show that there is a long run link between those variables and the EKC hypothesis was confirmed in long run.

Unlike of past researchers, (Ozturk & Acaravci, 2010) and (Inglesi-Lotz, 2016) carried out the research in the same country and he identified that the existence of EKC hypothesis is not hold. Therefore, the different study did not find a supported EKC hypothesis, example (Halicioglu, 2009) the study investigate the empirical dynamic causal link between the gross domestic product, trade , energy consumption and carbon dioxide emission in Turkey by using approach of boundaries testing for co-integration from 1960 to 2005. The data reveal that there is a long link , that the carbon dioxide emission are influenced by energy consumption , economic growth and trade and also the EKC hypothesis is not take into account. Based also on research of (Al-mulali & Binti Che Sab, 2012) examine the impact of energy consumption and carbon dioxide emission on economic growth in thirty sub-Saharan African countries . The findings revealed that energy consumption had an essential role in increasing economic growth in the studied economies, but at the consequence of excessive pollution, and the EKC hypothesis was not validated.

Moreover, the investigation of (Asumadu-sarkodie et al., 2016) on the causal link between CO2 emission , economic growth and population in Srilanka from 1971-2012 by using the Autoregressive distribution lag model a subsequent prediction of energy by using neural network. There was indication of a long run relationship between the CO2 emission, gross domestic product and population to the use of energy. However for this research the environment Kuznets curve have not tested. This finds from different authors make an attraction to examine the behaviors of Environment Kuznets Curve in Rwanda.

2.5.2. Trade and carbon dioxide emission

Several studies have found that trade has a positive impact on economic growth, political will, and technology development. The increase in global trade raises concerns it can be explained in three main factors for the impact of trade on greenhouse gas emission: scale, composition, and technology. Those Composition, scale, and method effects can all be influenced by increased trade openness (Farhani et al., 2014). To put it another way, the scale effect fundamentally means that as trade grows, so does production, energy consumption, and pollution. According to the composition effect, a country focuses on producing specific products due to its competitive advantage, and so rises in trade may result in increased or decrease pollution depends on whether the items produced by a country remain to be in energy-intensive sectors or not. Lastly, and most significantly, the technique impact refers to technology transfer between countries through trade flows, and so the use of cleaner technologies in commodity production may result in environmental gains. Countries should eliminate subsidies that assist carbon-intensive businesses to stimulate the establishment of more sustainable ways and, as a result, encourage increasing trade in green manufactured goods.

Thus, the numerous recent researches employ trade openness as an extra variable, but the results are mixed. (Halicioglu, 2009) and (Chen, Wang, et al., 2019) demonstrate that trade adds to pollution levels (Ben Jebli & Ben Youssef, 2015) and (Dogan & Seker, 2016) imply that trade reduces pollution. (Alola et al., 2019) investigate the effect of real income, renewable energy consumption, non-renewable energy consumption, trade openness on CO2 emissions Inside the EKC model, we used heterogeneous panel predicting methodologies with cross-section dependence for the leading countries mentioned in the Renewable Energy Nation Attractiveness Index. He found that trade openness reduces carbon dioxide emissions. The research for 25 OECD countries (Ben Jebli & Ben Youssef , 2015) examines the causative relationship between the carbon dioxide emission and gross domestic product, renewable and nonrenewable energy use, and international commerce. Surprisingly, boosting trade reduces CO2 emissions, according to the studies. (Jebli et al., 2016) look at the causal relationship between the CO2 emission, gross domestic product, nonrenewable and renewable energy consumption and (exports and imports) in Tunisia. The findings indicate that trade ratio has a favorable effect on carbon dioxide emission.

2.5.3 Literature of renewables and nonrenewable to CO2

Unlike the first and second section here we describes a literature on contribution of renewables and nonrenewable energy consumption on CO2 emissions. For instance, (Hove & Tursoy, 2019), (Kohler, 2013) find that using renewable energy instead of fossil fuels minimizes carbon dioxide emissions and

(Liu et al., 2017), (Dogan & Seker, 2016) ,(Cevik et al., 2021) (Güney, 2019), the authors find that renewable energy has a negative impact on carbon dioxide emission but nonrenewable energy has a positive impact on carbon dioxide emission. In any case, renewable energy is not the only source of energy; it can be used to create clean energy solutions that reduce the health and environmental effects of greenhouse gas emissions. (Adams & Nsiah, 2019) analyses the connection between renewable energy and carbon dioxide emissions for 28 Sub-Saharan African nations from 1980 to 2014. The results, based on the Fully Modified OLS and GMM estimate approaches, reveal that throughout the long run, both renewable and nonrenewable energy contributes to carbon dioxide emissions in the nations analyzed, but only nonrenewable energy has a strong positive influence on carbon dioxide emissions. However, in short run no longer shows whether carbon dioxide emission and gross domestic product has a U-Shape.

The research carried out by (Pata, 2018) indicates that the renewable energy use, hydropower consumption, and alternative energy use had no impact on CO2 emissions. However, (Awodumi & Adewuyi, 2020) looks into the impact of non-renewable energy on economic growth and carbon emissions in Africa's top oil producing economies from 1980 to 2015. He finds that, although a reduction in non-renewable energy usage slows growth in Nigeria, it cuts emissions. The impact on carbon emissions varies depending on the time and energy source. (Chen, Zhao, et al., 2019) His study looked at the effects of growth in the economy , renewable energy use and nonrenewable energy use on carbon dioxide emission in the regional level in China, as well as the EKC assumption. He discovered that renewable energy consumption had no effect on the EKC hypothesis in any of the three locations.

The study carried out by (Danish et al., 2017) who examined the Environmental Kuznets Curve (EKC) hypothesis in the context of Pakistan by looking at the significance of renewable and nonrenewable energy use on carbon dioxide emission. He discovered that not only is there bi-directional causality between dioxide emission and renewable energy use but also between the carbon dioxide emission and nonrenewable energy use and (Fatima et al., 2021) Examine how greater income and renewable energy affect environmental quality, which Show that when income rises, the ratio of renewable energy consumption to carbon dioxide emission decreases. Income growth adds more energy to the mix, which adds to emissions.

2.5. Conceptual Framework

The conceptual foundation for the links proposed in this work is shown in Figure below. A consumption-based carbon emission is a trade-adjusted measurement that accounts for the impact of foreign commerce. This value is modified to account for emissions from exports and imports. This metric is calculated by adding import emissions to domestic consumption demand from the government and households, then deducting exports (Ding et al., 2021). This measurement additionally included emissions from production in one country and consumption in another country.

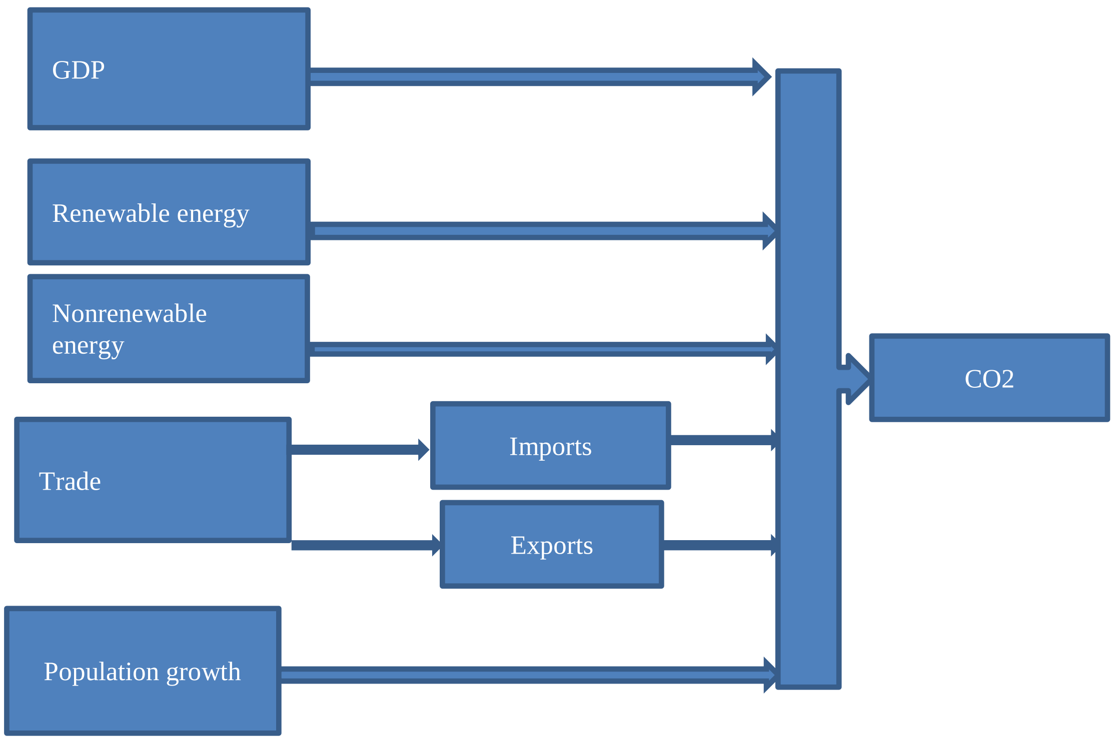

Figure 2: conceptual framework

Source: (Heryadi & Hartono, 2016)

Based on the models described above, as well as the models developed in the studies (Anqing Shi,2001) and (Shafiei & Salim, 2014). In the current study, CO2 emissions are used as a proxy for environmental impact. The GDP, population, and energy consumption variables in the model were used to cause a change in CO_2 emissions, as supported according to several studies such as (Sharma, 2011) and (Zaman et al., 2016) . Meanwhile, some many studies (Mert & Bölük, 2016) support the use of renewable energy consumption variables in the model and (Mbarek et al., 2018) in the model elsewhere here; population is a factor that could explain the size of a country.

According to (Shi et al., 2001), the larger a country's population, the significantly larger its people's economic activities which causes the increases of carbon dioxide emission, Research also supports the use of population variables in the model (Zhang et al., 2012) and (Destek & Ozsoy, 2015). The increase in economic activities, as represented by economic output, would then result in an increase in CO_2 emissions from energy use. Income, on the other hand, describes one's ability to consume goods and services. Increased income would increase demand for goods and services. According to (Rahmansyah et al., 2012), income is the primary factor driving the increase in CO_2 emissions from energy use.

Based on the review of various literatures, the authors claim that renewable and nonrenewable energy consumption have the positive impact on carbon dioxide emissions, whereas others pointed out that there is no link between the renewable energy , nonrenewable energy use and carbon dioxide emission. Therefore , the previous researcher use annually data contrary to this research we will use a quarterly time series data which help us to avoid biased estimate in examination of the impact of renewable and nonrenewable energy consumption on CO_2 emission in Rwanda**.**

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This Chapter provides the overview of the study procedure. It contains information about the method that is conducting this research as well as a justification for the usage of this method. The various steps of the research also are described in the chapter, theoretical framework, empirical specification model, source of data and variable measurement. The chapter ends with a review of the data analysis tools that will be employed.

3.2. Theoretical model

The Environmental Kuznets curve model suggests that pollution rises with income during the initial phases of economic growth, but that at a turning point, income increases lead to environmental benefit (Grossman & Krueger, 1991). Then, a neoclassical stochastic growth model orients the following empirical research. According to those theories, the variables have a long run relationship under consideration (Emeka & Kelvin, 2016). As a result, the statistical analysis methodologies used to validate the EKC hypothesis and the causal links between those indicators have ranged from Ordinarily Least Squares (OLS), Dynamic Ordinary Least Squares (DOLS), and Fully Modified Ordinary Least Squares (FMOLS) to spatial models. Econometric models that have investigated the EKC's applicability for numerous indicators have generated very different results.

Autoregressive distribution lag model (ARDL) approach has come up with the additional advantages. (i) The advantage of this technique is that it may be used to any series, whether they are I (0), I(1), or fractionally co-integrated (Johamen & Jtiselius, 1990) and (Wolde-Rufael, 2010) .(ii) Estimates for both the short and long-run can be made at the same time. (iii) The Engle Granger method's endogeneity issues and inability to verify the assumption on the predicted coefficients in the long term are addressed. (iv) It enables for varied suitable lags for the variables. (v) It uses a single reduced form equation (Ozturk & Acaravci, 2010).

3.3. The empirical model

The long-term connection between emissions of CO2, renewable and nonrenewable energy consumption, economic growth, trade, and population expansion can be modeled using the environmental Kuznets Curve hypothesis, as shown in formula following. Furthermore, the environmental pollution and economic growth have an inverted-U-shaped relationship, which may be statistically expressed by putting the variable of squared of GDP in the set of independent variables. The empirical pacification for the model is expressed as:

$$lCO2_t = \beta_0 + \beta_1 lGDP_t + \beta_2 lGDP_t^{\;2} + \beta_3 lRE_t + \beta_4 lNRE_t + \beta_5 lTD_t + \beta_6 lPOP_t + \epsilon_t$$

3.3.1. Pre-estimation test

3.3.1.1. Unit root test

Stationary data in time series data is a prevalent issue. Before applying the ARDL model, make sure that the variables are stationary. Traditional practical econometrics evaluation approaches are based on the premise of normality, which implies that the mean and variance don't really change over time. Many economic aspects, thus, do not have constant mean and variance, and these variables are referred to be unit root variables. In the presence of study data, the traditional technique (ordinary least squares, OLS) produces skewed and inaccurate estimates. In this study, we used a fantastic unit root test, such as PP (Phillips & Perron, 1988), (Dickey & Fuller, 1979). To confirm that each variable is stationary, we utilize the PP and ADF unit root tests.

3.3.1.2. Co-integration test

This follows all the procedures. To establish the long run link between the variables, we conducted the co-integration test after evaluating the stationary section of the time series. Aim will be achieved by using the Pesaran test in order to compare the F-test and upper bound. We reject Ho's null hypothesis, which claims there is no long run link here between variables, when the F-test is larger than the upper bound. In addition, this co-integretion test allows us to test the autoregressive distribution lag model for the variable that has been co-integreted.

3.3.1.3. Autoregressive distributive lag

This autoregressive distribution lag is a normal ordinary least square regression with dependent and independent variable lags as regressors. It is a technique for looking at co-integrating relationship among variables. Thus, the relationship between CO2 emissions, gross domestic product, renewable and nonrenewable energy usage, international trade, and population can be represented by a linear model, which can be stated as:

$$lCO2_t = f(lGDP_t, lGDP_t^2, lRE_t, lNRE_t, lTD_t, lPOP_t)$$

Therefore, the autoregressive distribution lag presented with the following formula.

$$\triangle lCO2_t = \beta_0 + \beta_1 lnCO2_{t-1} + \beta_2 lnGDP_{t-1} + \beta_3 (lnGDP_{t-1})^2 + \beta_4 lnRN_{t-1} + \beta_5 lnNRN_{t-1} + \beta_6 lnTD_{t-1} + \beta_7 lnPOP_{t-1} + \sum_{i=1}^{p} \beta_{8i} \triangle lnCO2_{t-i} + \sum_{i=1}^{p} \beta_{9i} \triangle lnGDP_{t-i} + \sum_{i=1}^{p} \beta_{10i} \triangle (lnGDP_{t-i})^2 + \sum_{i=1}^{p} \beta_{11i} \triangle lnRN_{t-i} + \sum_{i=1}^{p} \beta_{12i} \triangle lnNRN_{t-i} + \sum_{i=1}^{p} \beta_{13i} \triangle lnTD_{t-i} + \sum_{i=1}^{p} \beta_{14i} \triangle lnPOP_{t-i} + \epsilon_t$$

Where

- $\mathbf{lnCO_{2t}}$: is the logarithmic transformations of carbon dioxide emissions
- $\mathbf{lnGDP_t}$: logarithmic transformations t of GDP per capita
- $\mathbf{lnRN_t}$**:** logarithmic transformation t of renewable energy consumption per capita (Terajoules)
- $\mathbf{lnNRN_t}$: logarithmic transformation of Non-renewable energy consumption per capita (Terajoules)
- $\mathbf{lnTD_t}$: logarithmic transformation at time t of Trade ratio per capita
- $\mathbf{lnPOP_t}$: logarithmic transformation of population growth in year t,
- $\epsilon_{t:}$ is the white noise
- The letter $\boldsymbol{\beta_0}$**,** $\boldsymbol{\beta_1}$**,** $\boldsymbol{\beta_2}$ **,** $\boldsymbol{\beta_3}$ **,** $\boldsymbol{\beta_4}$, $\boldsymbol{\beta_5}$ and $\boldsymbol{\beta_6}$ present the coefficient to be estimated.

The square of lnGDP per capita is included to see if the Environmental Kuznets Curve (EKC) exists and if there is an inverse U - shaped pattern where a rise in income results in a decrease in lnCO2 emission ($\beta_3 < 0$). This methodological will be based on the following steps, test of Unit Root Stochastic by using Augmented Dickey-Fuller (1981) (ADF) test, to investigate the F-statistics (Wald test) for variables, examining Co-integration Test.

- Long-run relationship tested by F-test
- Null hypothesis(H_0): $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$
- Alternative hypothesis(H_1): $\beta_1 \neq 0$ or $\beta_2 \neq 0$ or $\beta_3 \neq 0$ or $\beta_4 \neq 0$ or $\beta_5 \neq 0$ or $\beta_6 \neq 0$

The results to be interprets will be obtained by using STATA software such as tables, figures and regression results.

3.4. Source of Data and variable measurement

In this study, Reid defined population as "all units bearing specific qualities that are of interest to the researchers." The population, as per the definition, refers to the targeted person or group of people who are participating in or selected by the investigator for his examination. As a result, this analysis relied on quarterly time series data for Rwanda. Due to unavailability of data for Rwanda, this research will use a sample size of 113 quarterly from 1990 to 2018.

The data was obtained from latest version World development indicator from 1990-2018, the variables that will be analyzed are CO_2 emissions, GDP, renewable and non-renewable energy use and international trade and Population growth all those have founded at world development indicator. Thus, the data is measured in different unit according to it equivalent measures. The CO_2 emissions per capita (in metric tons per capita), the gross domestic product (GDP) per capita in value added (constant 2010 US dollars) , non-renewable per capita (Terajoules (TJ)), renewable energy consumption per capita (measured in Terajoules (TJ)) , population growth and trade ratio (export+ import/GDP) in Rwanda. The Renewable energy is comprised naturally sources of energy like solar, nuclear energy and non-renewable energy is comprised of coal, natural gas, petroleum, and other liquids; and primary energy consumption (PEC) and international trade (export and import/GDP) and Population growth as number of people then after all data are transformed in quarterly data for the case of Rwanda.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1. Descriptive Analysis

The goal of this study, as stated above, is to look into the causal relationships between CO2 emissions, renewable energy, and nonrenewable energy usage. The data used is a quarterly time series data set that spans the quarterly data from 1990 to 2018. Three steps will be taken to complete the description. First, we use a visual representation to study the data's progression. CO2 emissions, gross domestic product, trade, population growth, non-renewable energy consumption, and renewable energy consumption all followed a similar pattern between 1990 and 2018.

Second, we are interested in seeing the data's correlation coefficients. Finally, we look at some descriptive analysis for the independent factors, such as mean and standard deviation, maximum, and minimum values. CO2 emissions, trade, population growth, nonrenewable, renewables, and output

4.1.1. Trends of variables

This section will discuss on the trends of variable by comparing its variability among the different years. This will help us to know how the variable changes along the different period.

Figure 3: Trends of variables

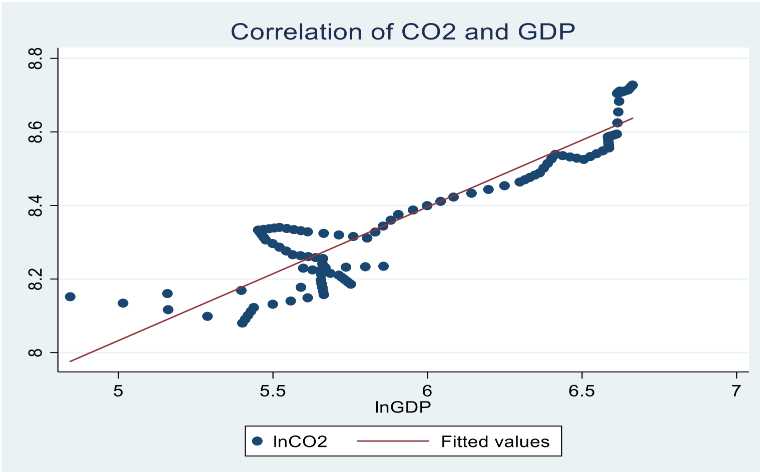

Figure 4 : Correlation between carbon dioxide emission and gross domestic product

The graphs above depict the above-mentioned trend of variables, which are transformed in logarithmic form from 1990 to 2018, as well as a comparison of whole variables. The gross domestic product, trade, population, and nonrenewable all follow the same trend as carbon dioxide emissions, as per the results of the trend. Furthermore, during the Genocide against Tutsi of 1994 lead to the disturbance of all economic activities and this later lead to the instability of all considered variables. Renewable energy, on the other hand, has maintained a consistent smooth trend in Rwanda, centrally to the scenario of the relationship between renewable energy consumption and the GDP in the same period of study, the carbon dioxide emissions and GDP have a positive association from 1990 to 2018.

4.1.2. Matrix of correlation

This is Table 1. Is going to describe the matrix correlation of the variable that we are going to use in this study. The result is that the independent variables GDP, population and trade, population growth are the perfect correlation with carbon dioxide emission as one variable increases; the other variable tends to also increase and nonrenewable energy and renewable have a strong correlation with carbon dioxide emissions. That is why all those variables affect carbon dioxide emissions as a source of climate change and global warming in Rwanda.

Table 1: Matrix of correlations

Variables	(lnCO2)	(lGDP)	(lNTR)	(lnPOP)	(lnRN)	(lnNRN)
(1) lnCO2	1.000					
(2) lnGDP	0.927	1.000				
(3) lnTR	0.969	0.878	1.000			
(4) lnPOP	0.975	0.888	0.959	1.000		
(5) lnRN	0.663	0.682	0.739	0.690	1.000	
(6) lnNRN	0.693	0.654	0.663	0.623	0.460	1.000

4.1.3. Descriptive statistics of variables

Table 2 displays the summary analysis for all dependent and independent variables. For the purposes of this study, real GDP is calculated in 2010 US dollars, while nonrenewable and renewable energy usage is computed in Terajoules (TJ), population growth is measured in people, carbon dioxide emissions are measured in metric tons of CO2 equivalence, and trade is measured in trade ratio in 2010 US dollars.

Over the sample period in Rwanda, the mean value of real gross domestic production is US $5.9 billion. The real gross domestic product varies between the US $4.84 billion and $6.7 billion. The degree of variability is also witnessed by the standard deviation of US $0.51billion, indicating that the data is not scattered away from the mean value. The mean of gross domestic product square has a mean of 8.38 billion in 2010US and varies between 2010US and $23.5 billion and 2010US to $44.4 billion, with a standard deviation of $6.04 billion scatted around its mean.

The variable trade is computed as a ratio of exports and imports. This means that the ration is shown as the rate of international trade for this study by referring to table 2. We have seen that the mean ratio is $20.7 billion and the range is between $19.1 billion and $22.32 billion. Afterward, the standard deviation is 0.87, which means that the scatted are around the mean.

The variable trade is followed by the population growth, which has a mean of about 16 million, and the minimum value is 15.6 million and the maximum is 16.3 million. However, its standard deviation is 0.23, which means that the variables are scattered at their mean. The renewable energy consumption has a mean value of 10.8TJ with a variation range of 10.1TJ to 11.2 TJ, with the degree of variability revealed by the standard deviation of 0.33 TJ, indicating that the data is distributed away from the mean value of the renewable energy consumption. The nonrenewable energy consumption has a mean value of 8.84TJ with a variation range of 8.64TJ to 9.27TJ, with the degree of variability revealed by the standard deviation of 0.14 TJ, indicating that the data is distributed away from the mean value of the nonrenewable energy consumption.

Table 2: Data description

	Mean	Standard Deviation	Minimum	Maximum
lnCO2	8.38	0.19	8.08	8.73
lnGDP	5.96	0.49	4.84	6.66
lnGDP2	35.7	5.84	23.5	44.4
lnTR	20.7	0.82	19.1	22.2
lnPOP	16.0	0.22	15.6	16.3
lnRN	10.8	0.32	10.1	11.2
lnNRN	8.84	0.14	8.64	9.27
Observations	113			

4.2. Stationarity test

As a prerequisite, the unit root test is performed using Phillip-(PP) Perron's and Augment dick-full test statistics based on the null hypothesis of a unit root and stationarity, respectively. To avoid erroneous regression, the unit root tests (PP and ADF) are used to verify for the stationarity of the time series analysis (Zhuang al, 2012). Table 3 shows that the null hypothesis of unit root fails to be rejected in the PP test at level, whereas the null hypothesis of stationary is rejected at 5% significant level. Furthermore, the results of the first differences show that not only is the null hypothesis of unit root rejected in the PP, but the null hypothesis of stationary cannot be accepted at 5% significant, implying that the time series are integration as I(1).

Table 3: Unit root test

	ADF at level		ADF at 1st Diff.		PP at level		PP at 1st Diff.	
obs	ADF test	ADF pvalue	ADF test	ADF pvalue	PP test	PP pvalue	PP test	PP pvalue
lnCO2	2.54**	0.99	-3.6	0.005	1.121**	0.99	-3.72	0.003
lnGDP	0.2	0.972	-5.42**	2.965	-0.345	0.918	-5.3**	4.69
lnTR	-1.11	0.707	-4.94**	0.00002	-0.967	0.76	-5**	0.1
lnPOP	2.56	0.999	-1.6*	0.482	0.83	0.99	-1.7*	0.41
lnRN	-1.606	0.48	-4.6***	0.0001	-1.68	0.439	-4***	0.0001
lnNRN	-0.653	0.858	-4.22**	0.0005	-1.3091	0.624	-4.3*	0.0003

4.3. Co-integration test

In the same way after to perform the pre-condition of analysis and it employee that the unit root is satisfying it condition , the next step is to run the co-integration test bound so that to run the autoregressive distribution n lag model . In the reason, we need to test the long run link between the variables.

Table.4 summarizes the output of the ARDL bounds test using the Pesaran criterion to determine the ideal model for the bounds testing. Table 4 demonstrates that the F-statistics (F=4.72) are greater than the upper bound (Fu=3.23) at the 10% level of significance, indicating that the null hypothesis with no co-integration between lnCO2, lnGDPPC, lnTR, lnRN, lNRN, and lnPOP is rejected. It indicates that there is a long-term relation between the factors. The results for Case 3 reveal that a value of Fs=4.722, which is bigger than the crucial value of upper bound Fub=3.230 at the 10% level and is null for no co-integration, can be rejected. It denotes that the parameters lnCO2, lnGDP, lnTR, lnRN, and lnNRN are co-integrated.

Pesaran/Shin/Smith (2001) ARDL Bounds Test

H0: no relation F=4.722 F-statistic,

Table 4: Co-integration test

Bound level	[I_0] L-1	[I_1] L-1	[I_0] L-05	[I_1] L-05	[I_0] L-025	[I_1] L-025	[I_0] L-01	[I_1] L-01
K(6)	2.10	3.24	2.5	3.7	2.8	4.0	3.16	4.42

Acceptable if F< regressors have a critical value I(0)
Reject if F is greater than the crucial value for I (1) regressors.

4.3. ARDL Regression Analysis

Due to the presence of the first steps and perform well as the variables are co-integrated, the ARDL regression should be estimated next. The ARDL regression is shown in Table 5. Table 5 shows that the rate of adjustments (ADJ) (lnCO2. = -0.695) is significantly negative at the 5% level, demonstrating the existence of a long-run equilibrium link between variables ranging from lnGDP, lnTR, lnPOP, lnRN, and lnNRN to lnCO2. Table 5 also demonstrates the factors' short-run dynamic linkages. In this study, the linear restriction test is employed to assess the combined impact of the separate outcomes at various times. The overall estimate demonstrates a short-run equilibrium link between variables ranging between lnGDP to lnCO2, lnTR to lnCO2, lnPOP to lnCO2, lnRN to lnCO2, and lnNRN to lnCO2. Furthermore, the study estimates long-run elasticities, which has policy implications.

In the long run, A 1% rise in lnGDP results in a 2.34 % increase in lnCO2, a 1% rise in lnPOP results in a 0.092 % rise in lnCO2, and a 1% rise in lnTR results in a 0.2 % increase in carbon dioxide emissions. Just 1 % rise in lnNR causes a 0.381 percent decrease in lnCO2, while a one percent increase in lnNRN causes. Furthermore, we are focused in the EKC connection by emphasizing on the signs of parameters associated to the lnGDP and lnGDP2 variables. Both in long and short-term analysis, the results show a positive sign for lnGDP and a negative sign for lnGDP2.

This suggests that in the context of Rwanda's economic, the EKC hypothesis is supported. Only the latter, nevertheless, has not yet achieved the tipping point output that allows it to reap environmental benefits. In the short run, the greatest value of ln GDP (6.66) is less than the turning point (7.01= (0.94/0.06)/2, but it is also smaller than the turning point in the long run. In the long term, it will stand as a turning point (6.50= (2341/0.18)/2), which was calculated by the proportion of the GDP parameter to the absolute amount of the double of the estimated GDP2 parameter. This finding means that Rwanda's economy continues to pollute the environment.

Table 5: long run and short run relationship

D.lnCO2	Coefficient	Standard error	t-test	P>t	[95%Conf.	Interval]
ADJ						
lnCO2						
L1.	-0.695	0.943	-0.04	0	2.513	3.122
Long run relationship (LR)						
lnGDP	2.341	9.662	0.024	0.008	21.302	25.984
lnGDP2	-0.18	0.797	-0.023	0.008	2.131	2.77
lnRN	-0.381	1.019	-0.03	0.001	2.074	2.111
lnNRN	0.174	0.463	0.038	0.007	0.958	1.307
Short Run relationship (SR)						
lnCO2						
LD.	0.042	0.577	0.007	0.009	1.37	1.454
lnGDP						
D1.	-0.94	3.458	-0.027	0.007	5.402	7.521
LD.	0.174	1.439	0.012	0.009	3.346	3.694
lnGDP2						
D1.	0.067	0.289	0.023	0.08	0.639	0.773
LD.	-0.021	0.126	-0.017	0.008	0.329	0.587
lnRN						
D1.	0.248	0.413	0.001	0.005	0.764	1.259
LD.	0.121	0.211	0.02	0.005	0.394	0.637

lnNRN						
D1.	-0.041	0.209	-0.002	0.008	0.552	0.971
LD.	-0.046	0.161	-0.02	0.007	0.441	0.848
_cons	-1.518	16.281	-0.01	0.009	41.355	43.319

4.4. Diagnostic test of ARDL model and stability

In order to make unbiased estimate the study estimate the residuals of independent variable for both for long run stability by using cumulative of sum (CUSUM) as well as to check the autocorrelation between the residuals.

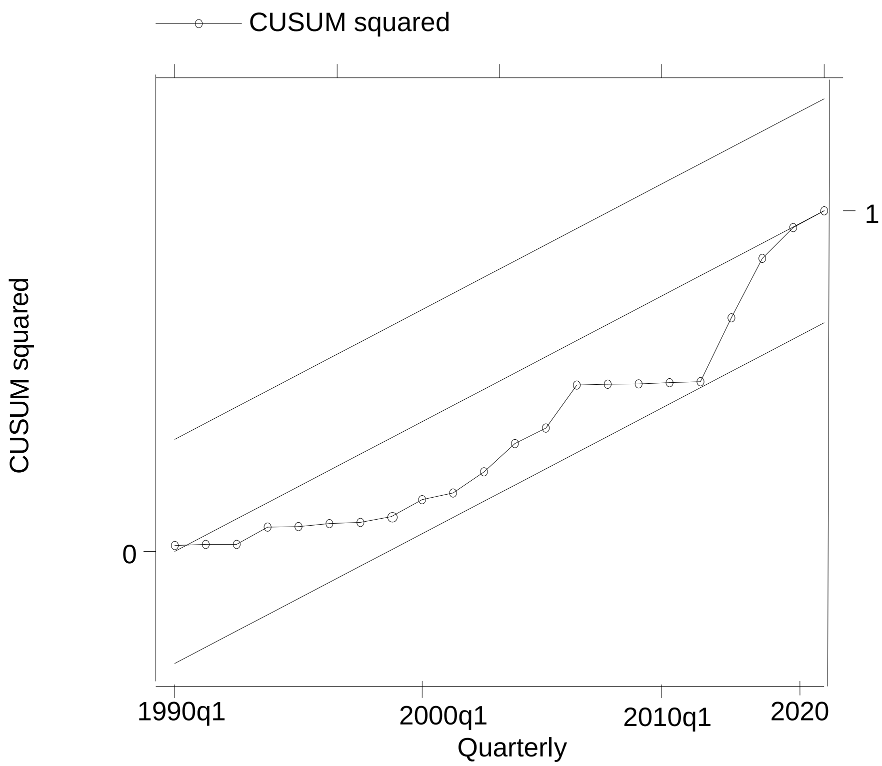

Figure 5: CUSUM Squared Stability of long run Relationship

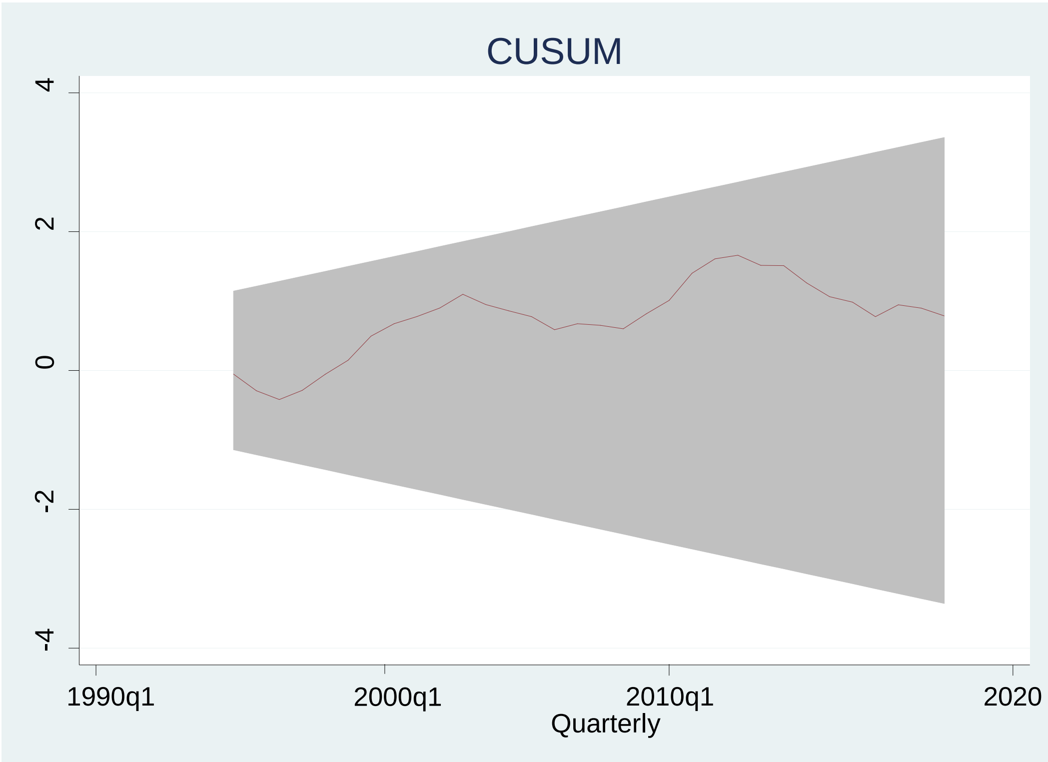

Figure 6: CUSUM for Stability of long run Relationship

The study explores the stability of the co-integration space that use the Cumulative sum and Cumulative sum of Squares tests. The results in Fig. 5 and 6 shows that the graphs in the CUSUM of Squares tests are within the 5% level of significance. This suggests that the ARDL regression model's equation parameters are stable enough just to generate unbiased statistical decisions.

Testing the autocorrelation

The Breusch- Godfrey is a one way we can use to test the autocorrelation between the residuals where (H0) null hypothesis state that there is no serial correlation between the residuals while (H1) state that there is a serial correlation between the residuals. From the results below that chi2=0.057 is greater than the p-value=0.02 which conclude that there is no serial correlation between the residuals.

Breusch-Godfrey LM test for autocorrelation chi2	df	Prob>Chi2
0.057	1	0.02

H0: no serial correlation

Testing the autocorrelation between the residuals of regression model .The one way we can use to test correlation among the residuals is Durbin-Watson where we can set the assumption.

Null hypothesis (HO): No correlation between the residuals

Alternative hypothesis (H1): The residual are correlated

Durbin-Watson d-statistic(6, 112) = .182 p-value =0.69

From the results above, the p-value is 0.69. Then this p-value is less than 5% of significant level, we cannot reject the null hypothesis and we conclude that the residuals are not correlated.

Testing for normality of data

According to the Skewness Kurtosis testing for normality of data which is a one way to test normality and based on the assumption of (HO) null hypothesis of data are normal distribution and (H1) alternative hypothesis of data are not normal distributed. The result below state that the p-value of skewness is greater than the 5% of significant level. The similarly to Kurtosis indicate that the p-value of kurtosis is greater than the 5% of significant level. Therefore, the null hypothesis of data are normal distributed cannot be rejected. Thus according to Skewness test for normality, the residuals are normal distribution.

Skewness/Kurtosis tests for Normality

				------ joint ------	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj_chi2(2)	Prob>chi2
myresidual	113	0.277	0.227	5.850	0.054

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

The main objective of this chapter is to explain the results and recommendations as well as the hint for the further researchers.

5.1. Discussion of findings

The main objective of this project was to look at the contribution of renewable and nonrenewable energy usage on carbon dioxide emissions. To minimize biased regression, we also used the the approach of autoregressive distribution lag model was used to analyze the effect of renewable, nonrenewable energy consumption, gross domestic product, trade, and population on CO_2 emissions in Rwanda, the quarterly data was used from 1990 to 2018. The objective of the research project was met by calculating the Phillip-and Perron's Augment Dick fuller unit root test statistical data, as well as the ARDL bound test and Autoregressive distributed lag regression analysis to forecast the long- and short run.

The study also estimated the impulse response analysis for VECM. Carbon dioxide emissions, gross domestic product, trade, renewable and nonrenewable energy consumption, and population are all co-integrated and have a long-run equilibrium relationship, according to the study's findings. Evidence from the Autoregressive distribution lag estimate of the short-run at different lags indicates that there is a short-run equilibrium relationship between variables ranging from GDP to CO_2 emissions, trade to CO_2 emissions, renewable to CO_2 emissions, nonrenewable to CO_2 emissions, and population to CO_2 emissions.

First, the Autoregressive distributed lag results support the validity of the Environmental Kuznets curve because the GDP variable has a positive sign and the GDP square variable has a negative sign. The anticipated GDP turning point, however, does not occur within the 1990–2018 period. This suggests that Emissions of co_2 might start with an improvement in Rwanda's Economy. The following of the first, the long-run coefficient obtained from ARDL has policy implications for Rwanda; In the long run, a 1% increase in GDP per capita increases carbon emissions by 0.15 percent, a 1% increase in trade increases co_2 emissions by 0.14 %, and a 1% increase in the population raises co_2 emissions by 0.2 percent. Whereas a 1% rise in renewable energy consumption reduces CO_2 emissions by 0.24 percent, a 1% increase in nonrenewable energy usage increases CO_2 emissions by 0.11 % in long run. The findings approve the results of the previous researchers like (Cevik et al., 2021), (Dogan & Seker, 2016),(Liu et al., 2017),(Kohler, 2013),(Hove & Tursoy, 2019)and (Güney, 2019) They discover that renewables has a negative impact on emissions, whereas nonrenewable energy has a positive impact on emissions in the country.

Therefore, Rwanda's increased use of nonrenewable energy adds to environmental degradation. It implies that Rwanda should undertake efforts to reduce its consumption of nonrenewable energy with a good objective to end of these issues: to reduce increase of CO_2 emission. In this way, Rwandan government should develop the energy policy in the way of energy conservation and efficiency . This approach may concentrate on intensive energy sectors such as using energy in the form of traditional fuels like wood , the transportation, households, and industries , which account for 8%, 82% and 6% of total energy consumption in Rwanda (Mudaheranwa et al., 2019).

This strategy will minimize internal energy use by modernizing infrastructures, incorporating technology breakthroughs, and organizing public awareness campaigns to motivate the people to use the renewable energy in order to make a clean energy Furthermore. These plans should be supplemented by a variety of actions, such as the introduction of energy-saving initiatives through the use of technical rules for energy-intensive vehicles and equipment.

Furthermore, excess supply and unnecessary usage should be avoided, and the rate of demand growth should be controlled to primary determinant energy and benefit from increased energy efficiency, and governments should establish new laws and measures to limit the use of fossil fuels. Renewable energy use has a negligible influence on CO_2 emissions, according to Autoregressive distributed lag estimates. In order to reduce Emissions of co_2, Rwandan government may invest in renewable energy consumption and develop regulations that encourage its use of renewable energy. As a result, it is vital to launch a strategy based on the realization of related investments, the modification of quality requirements, and the training of necessary human resources.

Renewable energy improvement has a massive high-cost issue. Renewable energy sources can be produced because of government subsidies due to their high costs. Furthermore, policymakers should encourage the attraction of foreign investors in energy sectors by addressing barriers associated with inadequate governance, cumbersome procedures, and an absence of tax breaks. As a recommendation, Rwandan authorities may create the environment that encourages the use modern energy like renewable energy sources in order to reduce environmental pollution and its consequences. Because of unobservable carbon dioxide emissions statistics for each form of energy. We may recommend that future researchers in this subject investigate the causative influence of each form of energy on carbon dioxide emission in Rwanda.

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Appendix 1: TABLE RESULTS OF LONG RUN AND SHORT RUN RELATIONSHIP

D.lnCO2	Coefficient	Standard error	t-test	P>t	[95%Conf.	Interval]
ADJ						
lnCO2						
L1.	-0.695	0.943	-0.04	0.038	2.513	3.122
Long run relationship (LR)						
lnGDP	2.341	9.662	0.024	0.008	21.302	25.984
lnGDP2	-0.18	0.797	-0.023	0.008	2.131	2.77
lnTR	0.201	0.341	0.049	0.007	0.633	1.035
lnPOP	0.092	0.749	0.012	0.009	1.741	1.924
lnRN	-0.381	1.019	-0.03	0.001	2.074	2.111
lnNRN	0.174	0.463	0.038	0.007	0.958	1.307
Short Run relationship (SR)						
lnCO2						
LD.	0.042	0.577	0.007	0.009	1.37	1.454
lnGDP						
D1.	-0.94	3.458	-0.027	0.007	5.402	7.521
LD.	0.174	1.439	0.012	0.009	3.346	3.694
lnGDP2						
D1.	0.067	0.289	0.023	0.08	0.639	0.773
LD.	-0.021	0.126	-0.017	0.008	0.329	0.587
lnTR						
D1.	-0.11	0.14	-0.032	0.046	0.452	0.632
LD.	-0.052	0.111	-0.047	0.006	0.325	0.82
lnPOP						
D1.	1.015	4.508	0.023	0.008	10.015	12.044
LD.	0.611	2.585	0.02	0.008	5.715	6.937

lnRN						
D1.	0.248	0.413	0.001	0.005	0.764	1.259
LD.	0.121	0.211	0.02	0.005	0.394	0.637
lnNRN						
D1.	-0.041	0.209	-0.002	0.008	0.552	0.971
LD.	-0.046	0.161	-0.02	0.007	0.441	0.848
_cons	-1.518	16.281	-0.01	0.009	41.355	43.319

Appendix 2: RESULTS OF UNIT ROOT TEST

name	dfuller_statistic	dfuller_cvalue	dfuller_pvalue	dfuller_lags	pperron_statistic	pperron_cvalue
var	-3.60518	-2.88927	0.005663	0	-3.72195	
var	-5.42747	-2.88927	2.97E-06	0	-5.3323	
var	-4.94154	-2.88927	2.89E-05	0	-5.00823	
var	-1.60147	-2.88927	0.482857	0	-1.72713	
var	-4.61635	-2.88927	0.00012	0	-4.64621	
var	-4.22503	-2.88927	0.000597	0	-4.34252	