ENVIRONMENTAL EMISSIONS AND LIFE EXPECTANCY IN NIGERIA

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CERTIFICATION

The undersigned certify that this project was carried out by **ORIAKHI OSASERE FELIX** and was approved as adequate in scope and content in partial fulfillment of the requirements for the award of Master of Science (M.Sc.) degree in Economics, University of Benin, Benin City.

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DEDICATION

This research work is essentially dedicated to God Almighty the Giver of Life and Wisdom, and for his Unfailing Love and Mercy upon my Life and for making this research a Success.

I also dedicate this work to my Parents Mr. and Mrs. Oriakhi and my late uncle Frank Oriakhi whose continued love, care, moral and financial assistance has seen me throughout the course of my programme.

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My greatest appreciation goes to God Almighty the Giver of Life and Wisdom, and for his Unfailing Love and Mercy upon my Life and for making this research a Success.

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May God reward you all abundantly, Thank you.

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ABSTRACT

Background: *human beings engage in a number of activities such as extractions and mining, manufacturing, transportation, agricultural cultivation (e.g., bush burning), food and mineral processing, as well as other anthropogenic activities that exert significant impact on the environment. The adversative consequence of environmental emission on human habitation, food production, human migration and human health is significantly felt through the decline in average life span of humans.*

Objective and methodology: *This study evaluated the effects of environmental emissions on life expectancy with particular emphasis on Nigeria. The autoregressive distributed lag (ARDL) and bounds testing approach was utilized in analyzing the data to be employed in this study. In addition, the study employed annual data set for a period of fifty (50) years spanning 1970 to 2019. Similarly, data on Carbon (iv) dioxide emissions in Nigeria (million tonnes), Methane emissions (million tonnes) in Nigeria and Nitrous Oxide emissions (million tonnes) in Nigeria were derived from the Global Carbon Project (2020), while data on per capita income was obtained from World Development Indicators of the World Bank (2020). Similarly, data on Life expectancy at birth (years) was sourced from the United Nations World Population Prospects (2019).*

Results: *The coefficient of Carbon (iv) dioxide emissions was negative in the short run estimated results. However, it was positive in the long run. similarly, Carbon (iv) dioxide emissions was statistically significant at 1% critical level in the long run and short run estimation results respectively. Similarly, the coefficient of Methane emissions was negative and statistically significant at 1% critical level in the short run estimation results. Also, the result indicated that Methane emissions was negative and statistically significant at 1% critical level in the long run estimation results. Furthermore, the coefficient of Nitrous Oxide emissions was positive both in the short run and long run estimation results. The result further established that while the coefficient of Nitrous Oxide emissions was statistically significant at 10% critical level in the short run, it became statistically significant at 1% critical level in the long run. Similarly, the coefficient of real GDP per capita was positive both in the short run and long run estimation results in the period of assessment. The result further established that while the coefficient of real GDP per capita was statistically insignificant in the short run, it was found to be statistically significant at 1% critical level in the long run estimation results.*

Recommendations: *It was recommended that the Nigeria should adopt a stringent environmental control measures that will help reposition the country's environment through enhanced carbon control policy. Specifically, it is recommended that Carbon Taxes should be introduced to help reduce the unwarranted industrial processes contributing a large volume of the total greenhouse gas emissions increase in the country. To mitigate the negative effects of Methane emission gases, there is an urgent need to draft relevant policies to regulate all human activities that trigger the release of methane gases into the ecosystem especially in the area of production and transport of coal, natural gas, and oil, livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills. The moribund environmental regulations should be reactivated to ensure the reduction of Methane emissions across the 774 local government areas in Nigeria. it was also recommended that the government and all relevant stakeholders in the agricultural and industrial sectors to work collaboratively in ensuring that policy effort are implemented to limit the frequent release of Nitrous oxide (N2O) emission in the course of agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater.*

CHAPTER ONE

PREAMBLE

1.1 Introduction

Health plays a significant role in the development of any nation (Weil, 2020; Lilley, Lilley, & Rinaldi, 2020). This is because a healthy nation is a wealthy nation. When individuals are healthy, they will have the capacity to work and earn a living for themselves. They will also have the ability to contribute meaningfully to the growth and development of the society where they live. When a nation is healthy, such country will tend to spend less on health-related challenges.

Essentially, life expectancy is the anticipated average age which individual member of a given population group would have attained at the point of death. Thus, a population with increasing life expectancy tends to live longer in "full health" than the one with lower expectancy index. There is a strong link between good health and life expectancy because, as human live a healthier life, all other things being equal, the expected number of years they expect to live in "full health" will tend to increase (World Health Organization, 2019).Thus, the need to promote good health across all strata of life. This was the primary focus of the Sustainable Development Goals (SDG). For instance, Goal 3 of the SDG is “to ensure healthy living and promote well-being for all at all ages (Good Health)”.

According to World Health Organization (2020),global life expectancy is 73.3 years (70.8 years for male and 75.9 years for female). Also, WHO (2020) regional report on life expectancy and healthy life expectancy indicates that, Africa has the lowest life expectancy of 64.5 years (62.4 years for male and 66.6 years for female), while Americas have 77.2 years (74.5 years for male and 79.8 years for female). Europe has the highest life expectancy of 78.2 years (75.1 years for male and 81.3 years for female), while Eastern Mediterranean region has life expectancy of 69.7 years (68.3 years for male and 71.3 years for female). Similarly, South-East Asia has life expectancy of 71.4 years (69.9 years for male and 73.1 years for female), while Western Pacific region has life expectancy of 77.7 years (74.8 years for male and 80.8 years for female).

Life expectancy varies across different countries in the globe. For instance, the average lifespan of individual in Eswatini is 30-40 years (The World Fact book, 2021), while that of Japan is 84.3 years. The country (Japan) has the highest index of life expectancy globally (WHO, 2020; Ikeda, Saito, Kondo, Inoue, Ikeda, Satoh & Shibuya, 2011).Though the United Nations Development Programme (2020) put Japan's figure at 84.6 years, trailing behind Hong Kong who has life expectancy of 84.9 years. Similar report from the WHO (2020) revealed that, the average lifespan of individual in South Korea is 83.3 years, while that of Sweden is 82.4 years.

Germany has life expectancy of 81.7 years, while that of Seychelles is 73.3 years. The United Kingdom has life expectancy of 81.4 years, while that of USA is 78.5 years. Similarly, South Africa has life expectancy of 65.3 years. In the context of Nigeria, the average life expectancy is put at 62.6 years (61.2 years for male and 64.1 years for female), while Lesotho has the least life expectancy of 50.7 years (47.7 years for male and 54.2 years for female). Central African Republic however has the second lowest figure of 53.1years (50.2 years for male and 56.3 years for female).

There is no gain saying that, man is surrounded by a stock of multi-dimensional constraints in his desire to improve his well-being as well as the condition of his society. These constraints have however limited his ability to cater for his daily needs, thus, compelling him to seek for the best solutions with the aid of the limited resources available to him. In bid to obtain these resources, humans constantly interact with the environment. Thus, the interaction between man and the natural environment is as old as mankind. In the course of this interaction, individuals engage in a number of activities such as extractions and mining, manufacturing, transportation, agricultural cultivation (e.g., bush burning), food and mineral processing, as well as other anthropogenic activities that exert significant impact on the environment.

Essentially, environmental sustainability forms the core of the Goal 17 of the United Nations' Sustainable Development Goals (SDGs), which revolves around the "Protection, restoration and promotion of sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (Mohieldin& Caballero, 2015). Nevertheless, through man-induced activities such as transportation, manufacturing, etc., harmful gases are released into the ecosystem. Oil exploration and gas flaring contribute to environmental pollutions on a daily basis. Daily manufacturing activities, food and chemical processing also contribute to the environmental hazards that mankind is exposed to, on a daily basis. In the process of agricultural cultivation, a number of farmers still adopt the traditional means such as bush burning, which triggers emissions of carbon (ii) oxide to the atmosphere and these harmful gases are often inhaled by humans.

Similarly, Methane (CH_4) gases are discharged in the course of producing and transporting oil, natural gas, and coal. These gases are also emitted from "livestock and other agricultural activities, land use and by the decay of organic waste in municipal solid waste landfills" (United States Environmental Protection Agency, 2021).According to the United States Environmental Protection Agency (2021), Carbon dioxide (CO_2) account for the largest proportion of the global greenhouse gas emissions across several sectors of the global economy. However, it is needful to establish that, a significant volume of methane (CH_4) as well as nitrous oxide (N_2O) contribute to the environmental emission pool. The release of these gases usually occurs during fossil fuels (such as coal, oil, and natural gas) combustion in the process of generating power and electricity.

It was further revealed that "global carbon emissions from fossil fuels have significantly increased by about 90%, with emissions from fossil fuel combustion and industrial processes contributing about 78% of the total greenhouse gas emissions increase from 1970 to 2011. Agriculture, deforestation, and other land-use changes have been the second-largest contributors" (IPCC, 2014).Similarly, USA, the Russian Federation, the European Union, Japan, India, and China account for the largest volume of carbon dioxide (CO_2) emissions globally (EPA, 2021, Boden, Marland& Andres, 2017). These emissions result from gas flaring, fossil fuel combustion and cement manufacturing.

In the submission of Igbinedion (2019), the pursuit for quicker advancement of the domestic economy has triggered a significant rise in both production and consumption of goods and services leading to persistent increase in all kinds of pollution. Unfortunately, these harmful circumstances have become a source of worrisome threats to both human well-being as well as the environment. Most of these environmental hazards are created in the country's compactly populated cities where lots of economic activities take place. In the light of the increasing level of economic activities in those urban areas, pollution accompanying the rising daily industrial and automobile emissions leads to both decreasing human life span as well as increase in the "depletion of ozone layer" (Igbinedion, 2019).

The subject of environmental emission has thus remained a recurring object of global discussion with increasing threats to "the sustainable development of socio-economic and agricultural activities of any nation" (Adejuwon, 2004)in addition to the entire human survival. In the submission of Osabohien, Oluwatoyin, Aderounmu, and Olawande (2019), the constant interaction between thenatural environmentand humankind has triggered a significant rise in greenhouse gas (such as CO2) secretion into the atmosphere in the last four decades. The implication of these emission is that, they contribute to global warming. Joseph, Fredrick, Romanus, Ambrose, and Tochukwu(2018) averred that the adversative consequence of environmental emission on human habitation, food production, human migration and human health is significantly felt through the decline in average life span of humans.

1.2 Statement of the Research Problem

In recent times, the level of economic activities in Nigeria has been on the increase. This presents avenues for the generation of harmful gases to the environment. The effects of these gases can certainly not be over-emphasized. Thus, arising from the harmful effects of environmental secretions on both mankind and the environment coupled with efforts to limit further rise in carbon dioxide (CO2), both the industrialized and emerging nations are making growing exertions to create and adopt other sources of fuel to meet daily energy requirements especially for transportation activities. For instance, contemporary studies of Armeanu, Vintilă, Andrei, Gherghina, DrăgoiandTeodor (2018) and Marjanović, Milovančević andMladenović (2016)have established that the Nigeria's transportation sector accounts for a significant proportion of the environmental emissions adduced to be the key factor that contributes to increasing rate of global warming.

World Bank (2019) report indicated that CO2 emissions from gaseous fuel consumption (% of total) in Nigeria rose significantly from about 3.73percent in 1980 to 17.71percent in 2010,25.13percent in 2014and 26.47percent in 2016. Similarly, Life expectancy at birth, total (years) rose from 45.333 in 1980 to about 50.896 in 2010, 52.672 in 2014 and 53.541 in 2016. This trend negates the conventional expectation that a rise in the emission concentration level will trigger a decline in the quality of life of individual, thus, leading to a deterioration in the expected average lifespan of mankind.Thus, one of the problems cited in this study is the fact that the increase in CO2 emission over the yearsexert deleterious effects to the well-being of individuals which is not reflected in the trend in Life expectancy in Nigeria as revealed above. This is the motivation for this study.

In similar revelations from earlier study of Igbinedion (2019), empirical studies linking environmental emissions and life expectancy are still few in the context of Nigeria. Specifically, earlier studies of Magbagbeola (2001); and Iyoha (2009); only focused on the petroleum industry-induced pollution, while other studies such as Nwodo, Ozor, Okekpa and Agu (2018); Gambo, Ishak, Ismail and Idris (2018); and Alege and Ogundipe (2013); invested much attention in assessing the link between environmental emissions and economic growth.

To further broaden the research gap, the few identified studies that assessed similar linkage in the context of the transportation sector(transportation emission)were conducted in some designated states Nigeria. Thus, these studies were devoid of national coverage. Examples of such earlier studies include Usman, Abdulhamid, Gwadabe, Usman, Isah and Mallam (2017);Abam and Unachukwu (2009), Osuntogun and Koku (2007); Jerome (2000); among others. The major challenge associated with such state-centered studies with limited scope is that they cannot be sufficiently adopted for policy analysis aimed to influence the Nigerian economy as a whole. This is because, such state-centered studies may be quite misleading when extended to national economic discussions as the economic fundamentals of one state may vary significantly with another and the economic trend in one state cannot truly represent the dynamics of the Nigerian economy as a whole.

Another key problem noted in the previous studies is that, most of these studies employed data whose scope currently lag behind time, thus questioning the ability of such studies to address current policy issues. For instance, study of Amuka, Asogwa, Ugwuanyi, OmejeandOnyechi (2018)utilised data spanning 1995 to 2013, whileAgbanike, Nwani, Uwazie, Uma, Anochiwa, Igberi and Ogbonnaya (2019) only covered the period 1971 to 2014.In deep recognition of the fact that the Nigerian economy has witnessed series of activities that may have exerted significant impacts on the environment in the last one decade, such empirical gap will tend to question the significance of such policy endorsements. It is against this backdrop that this present study is designed to empirically evaluate the effects of environmental emissions on life expectancy in the context of Nigeria.

1.3 Research Questions

In view of the above research problems, this study seeks to address the following major questions;

i. What is the effect of Carbon dioxide (CO2) emission on life expectancy in Nigeria?

ii. What is the effect of Methane (CH4) emission on life expectancy in Nigeria?

iii. What is the effect of Nitrous oxide (N2O) emission on life expectancy in Nigeria?

iv. What is the effect of Economic welfare on life expectancy in Nigeria?

1.4 Objectives of the Study

The main objective of this study is to empirically evaluate the effects of environmental emissions on life expectancy in the context of Nigeria, The specific objectives are to;

i. determine the effect of Carbon dioxide (CO2) emission on life expectancy in Nigeria.

ii. determine the effect of Methane (CH4) emission on life expectancy in Nigeria.

iii. ascertain the effect of Nitrous oxide (N2O) emission on life expectancy in Nigeria

iv. evaluate the effect of Economic welfare on life expectancy in Nigeria.

1.5 Hypotheses of the Study

In line with the above research objectives, the following null hypotheses will be tested in this study.

Ho_1: Carbon dioxide (CO2) emission does not have significant effect on life expectancy in Nigeria.

Ho_2 Methane (CH4) emission does not have significant effect on life expectancy in Nigeria.

Ho_3: Nitrous oxide (N2O) emission does not have significant effect on life expectancy in Nigeria.

Ho_4: Economic welfare does not have significant effect on life expectancy in Nigeria.

1.6 Significance of the Study

The outcome of this study will be beneficial to environmental/health experts, researchers, academic scholars, the government/policy makers and environmental agencies within the domestic economy and at the international level.

1.6.1 Policy Makers

Specifically, the outcome of this study will help gain more insights into the dynamics of the various environmental gas emissions and how these gases have influenced the general health outcomes of individuals particularly in Nigeria. The outcome of this study is hoped to be found useful by the government, the ministry of health, the ministry of environment and other environmental bodies to ascertain how well the release of the various emission gases across several economic sectors can influence significant changes in the life expectancy in Nigeria as well as devising measures to achieve significant improvements in the implementation of relevant environmental policies in the country. The outcome of the study will also enable the various economic sectors to realize the deleterious effects of their activities on the ecosystem while deploying new strategies to curb environmental emissions for better health and safety practices.

1.6.2 Management/Heads of Organizations

The outcome of this study will also assist management of both public and private organisation such as the transportation companies, food and chemical industries, cement manufacturing companies, farm managers, among other, to plan their operational strategies as well as employing means to meet the various environmental health policies and safety standards with a view to promoting increasing life expectancy in the country. Specifically, it will assist the federal and states ministries of environment to plan and implement proper environmental monitoring framework to ensure full compliance to all environmental laws by both individuals, firms and government agencies responsible for various emissions in the country. It will further highlight areas that require fresh investment in alternative energy sources in order to mitigate climate change effects on humans' health.

1.6.3 Practitioners

The study will also enable practitioners, prospective and existing energy producers/consumers to gain more understanding of the effects of the various environmental gas emissions and carve out avenues to reduce such emissions concentrations in to the ecosystem. The independent environmental practitioners will immensely benefit from the outcomes of the study in the area of fresh information and in-depth understanding of the trends in the various environmental gas emissions and how these gases have affected the general health outcomes of individuals particularly in Nigeria.

1.6.4 Body of knowledge

Finally, judging from the significant research gaps in the current literature on environmental emissions and general health outcomes of individuals particularly in Nigerian, this study is thus another attempt to add fresh breath to the subject matter, thereby providing fresh insights into the long-term effects of environmental emissions on life expectancy particularly in Nigeria. Thus, it is hoped to contribute to existing literature thereby expanding the knowledge scope of the subject matter with further empirical evidence from the Nigerian environment and health sector.

1.7 Scope of the study

The focus of this study is to empirically examine effects of environmental emissions on life expectancy with particular emphasis on Nigeria. Thus, empirical discussions will be established on three key independent variables which include Carbon dioxide (CO2) emission, Methane (CH4) emission as well as Nitrous oxide (N2O) emission. Similar discussion will also be drawn from the controlling/intervening effect of economic welfare in the course of empirical analyses in this study.

In addition, to capture the long-term effects of the above-mentioned environmental emission gases on life expectancy (the response variable), the study will employ annual data set for a period of fifty (50) years spanning 1970 to 2019. This is to further account for more degree of freedom, while absorbing relevant periods of the various environmental policy reforms in the country into the empirical analysis.

1.8 Organisation of the Thesis

This study is structured into six (6) different chapters. The first chapter encapsulates the preamble, which presents the general overview of the study, statement of problem, purpose of the study and, provides a set of relevant research questions, objectives of the study, hypotheses of the study, significance of the study, scope of the study and the organisation of the thesis.

Chapter two presents the background to the study with specific emphasis on the Concept of environmental emissions and their transmission channels, concept of life expectancy, stylized facts of environmental emissions and life expectancy in Nigeria. Chapter three further presents the review of relevant literature on the subject matter. The chapter essentially borders on the review of environmental theories, theories of longevity/ life expectancy, methodological review, previous empirical studies in Nigeria and other countries. The last segment of the chapter presents the analysis of empirical gap in the literature.

Similarly, chapter four focuses on methodology of study where choice of theoretical framework, model specification, estimation technique, the data description, measurement and sources as well as the apriori expectations of the study were identified. Chapter five entails data presentation and analysis with relevant policy implications of the research findings, while chapter six discusses the findings of study; from which conclusions are deduced and recommendations drawn.

1.9 Definition of Terms

i. **Environmental emissions:** this refers to the release of harmful substances to the ecosystem with the possibility of exerting negative effects on both humans and animals.

ii. **Carbon dioxide (CO_2) emission:** This are the gases that are "released into the ecosystem through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle".

iii. **Methane (CH_4) emission:** "This is the release of methane gases into the ecosystem through various activities such as production and transport of coal, natural gas, and oil, livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills".

iv. **Nitrous oxide (N_2O) emission:** this are the gases emitted into the ecosystem in the course of "agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater".

v. **Economic welfare:** this is the degree or level of economic prosperity as well as the quality of living standards of the individuals in a given economy. Economic welfare can be measured using per capita income, literacy, levels of pollution, quality of housing among others).

vi. **Life expectancy:** this is the average age which individual member of a given population would have attained in "full health" at the point of death.

CHAPTER TWO

BACKGROUND TO THE STUDY

2.1 Introduction

Like several other evolving economies in Africa, Nigeria is faced with high rates of poverty coupled with extremely low domestic savings, unfavourable general government balance, high population growth rate, and low income as income is largely expended on consumption spending. The poor responses to resource shortages in Africa in general and Nigeria in particular, have exerted adverse effects on the general wellbeing of the people. This can be explained by the rising cases of displacement of persons, sickness and hunger, loss of jobs, and ultimately poor economic achievements.

The declining economic performance leads to loss of economic welfare to the society and thus, compels most households to resort to the use of traditional energy sources such as burning of fuel for domestic cooking activities. For instance, the United Nations Development Programme (UNDP, n.d) reports that "approximately 60% of the global greenhouse gases responsible for climate change is attributed to global energy production". Similarly, "3 billion people representing over 40% of the global population rely heavily on environmentally poisoning and unhealthy fuels for daily food processing" (UNDP, n.d).

The concept of environmental emission has become more antithetical not only to the sustainable development of any nation, but to the entire human survival. Specifically, environmental emissions have been known to increase the average global temperatures thereby altering the atmospheric composition of the earth, leading to Global Warming. With the rising level in temperature globally, local rainfall patterns are changing, ecological zones are shifting, the seas are warming and ice caps are melting (IPCC, 2007). These increased extremes and variability in climate leads to severe damages of critical infrastructure and assets that underpin community health and wellbeing.

This chapter therefore discusses the concept of environmental emissions and their transmission channels, concept of life expectancy, stylized facts of environmental emissions in Nigeria, stylized facts of Carbon (iv) dioxide (CO2) emissions in Nigeria, stylized facts of Methane emissions in Nigeria, stylized facts of Nitrous Oxide emissions in Nigeria, stylized facts of Other Gases (HFC, PFC and SF6) emissions in Nigeria as well as stylized facts of life expectancy in Nigeria. The chapter also examines the extent to which the Nigerian environment has been polluted by the various emission gases over the years.

2.2 Conceptual Issues

A well-articulated exposition of the key concept, environmental emissions and life expectancy is therefore beneficial for gaining requisite understanding of their meaning and how a well-designed and effectively implemented environmental and health policies would help in promoting good public health through the minimization of emission rates in the country. This section therefore explains what constitutes environmental emissions as widely adopted across the world.

2.2.1 Concept of Environmental Emissions and their Transmission Channels

Essentially, environmental emission refers to alterations in the eco-system and environmental temperatures that are often caused by human and natural events. Human beings contribute to environmental emissions through a range of household and industrial activities. It refers to an increase in average global temperatures there by altering the atmospheric composition of the earth, leading to Global Warming. Global warming simply refers to observable variations in the average temperature of earth's atmosphere and its oceans (Awosika, 1992).

The rise in the level of temperature globally has triggered significant change in local rainfall patterns, ecological zones are shifting, the seas are warming and there are recurring cases of ice caps melting (IPCC, 2007). Several research reports opined those Sub-Saharan African countries are mostly affected by variations in climatic patterns, as these tropical areas stand to experience some of the most severe effects from environmental emission and agriculture which takes a significant part of employment and food provision in Africa is the most sensitive to climate variability.

The challenges of environmental emission became so pronounced that in 1992, at the Rio Earth Summit Agenda, the United Nations Framework Convention on Climate Change (UNFCCC, 2007) was signed as the first commitment of the world to control the emission of Green House Gases. The UNFCCC constitutes the crucial global discussion forum on environmental emission as to the scope and timing of a potential agreement to combat environmental emission issues globally.

Subsequently, the Kyoto Protocol was signed on 11 December 1997by more than 55 countries, though became effective on 16 February 2005. The aim of the protocol was to carve out avenues through which the world can reduce the GHGs emission through the official setting of the benchmark for GHGs emission in industrialized nations (UNFCCC, 1998). Essentially, “The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that global warming is occurring and that human-made CO_2 emissions are driving it”(Nordhaus & Boyer, 1999; Böhringer, 2003; Grubb, 2003).

The Kyoto Protocol of 1997 set a minimum standard of 5.2% annual emission cut for the 2008-2012 period. This was less than the hitherto 1990’s acceptable level. The Kyoto Protocol sets up four mechanisms which developed countries may use in complying with part of their GHGs emission reduction commitments. These include “Carbon Balance, Market for Pollution Permit (Emission Trading), Joint Implementation and Clean Development Mechanism” (Clapp, Leseur, Sartor, Briner & Corfee-Morlot, 2010;Chevallier, 2011;Liu, Chen, Zhao & Zhao, 2015;Naik, Unnikrishnan, Singh&Nimkar, 2016;Feng, Li, Zhang, Gong & Yang, 2021;Wu & Zhu, 2021;Wang, Zhang, Su, Shen, Li& Li, 2021).

Following the financial crisis of 2007/08, there was a significant cut in the global rate of environmental emissions (Shishlov, Morel, & Bellassen, 2016). For instance, Shishlov, Morel, and Bellassen (2016) submitted that the highest level of success in emission decreases was attributed to the erstwhile Eastern Bloc nations following the disbanding of the Soviet Union which brought about a significant decline in the emissions of those countries in the early 1990s.The United Nations Environment Programme (2012) however established that, there was a 32% rise in the global emissions from 1990 to 2010, notwithstanding the reduction in emissions by the 36 developed countries that made up the defunct Eastern Bloc nations.

The Doha Amendment to the Kyoto Protocol was signed as a second commitment period in the year 2012. During the Doha Amendment to the Kyoto Protocol, there were 37 nations to the commitment. These include Ukraine, the European Union (and its then 28 member states, now 27), Switzerland, Norway, Liechtenstein, Kazakhstan, Iceland, Belarus, and Australia. Ukraine, Kazakhstan, and Belarus pulled out of the Kyoto Protocol a few months later (Figueres, 2012). It was further established that "Japan, New Zealand, and Russia" were the three countries that successfully shared in the implementation of the Kyoto's first-round. Nevertheless, these countries these countries did not see the relevance of proceeding with "new targets in the second commitment period".

Although, there were other industrialized nations who failed to brace up the train of the second-round targets. They include the diplomatic withdrawal from the Kyoto Protocol by the government of Canada in addition to the United States failure to ratify the agreement in the year 2012. According to the United Nations Framework Convention on Climate Change (2021), "as of 28 October 2020, 147 Parties deposited their instrument of acceptance, therefore the threshold for entry into force of the Doha Amendment was achieved. The amendment entered into force on 31 December 2020".

Environmental emission is primarily caused by increases in Green House Gas emission (GHG), CO_2 emissions from liquid fuel consumption, gaseous fuel consumption, electricity and heat production and manufacturing industries and construction, Methane emissions (CH_4), Nitrous oxide emissions (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Carbon hexafluoride (CF6), through industrial and agricultural activities, burning of wood, raising of lives stock, bush burning, decomposition of organic waste, combustion of solid waste and burning of fossil fuel (natural gas, oil and coal).

According to the United States Environmental Protection Agency (2021), Carbon dioxide (CO_2) emission accounts for the largest share of the global greenhouse gas emissions across several sectors of the global economy. Though, methane (CH_4) as well as nitrous oxide (N_2O) contribute to the environmental emission crisis globally (United States Environmental Protection Agency, 2021). The release of these gases usually occurs during fossil fuels (such as coal, oil, and natural gas) combustion in the process of generating power and electricity.

As noted earlier, human activities have represented the major contributors to the global warming for over five decades (Melillo, Richmond & Yohe, 2014). Specifically, carbon dioxide, methane, nitrous oxide, and some specific synthetic substances, are all forms of Green House Gases that trap some of the Earth's outward energy, hence recollecting heat in the atmosphere. When this heat is constantly trapped from the atmosphere, there will be changes in the radiative balance of the Earth. This yields a significant imbalance between the amount of energy generated from the sun as well as the amount that is discharged from Earth.

The dynamics atmospheric temperature translates into global warming which exert significant effects on different facets of climate, such as surface air and ocean temperatures, sea levels and precipitation. Another notable effect of climate change is deterioration in human health, distortions in agricultural yields, pollution of water resources, poor plant growth, threat to wildlife, among other. A number of these greenhouse gases can live in the atmosphere of a long period of time, with the potential to cause harm through the release of airborne. When these gases stay in the atmosphere for long, they become globally mixed in the air and their absorptions become major emissions sources globally.

Synthetic halocarbons are greenhouse gases that are discharged solely from human activities, while others such as carbon dioxide occur naturally at elevated levels sequel to human inputs. Environmental emissions often occur as a result of burning of fossil fuels in the course of generating electricity and transportation activities. Agricultural activities, poor waste management and treatment activities, as well as several industrial procedures contribute to climate change through environmental emissions (United States Environmental Protection Agency, 2021).

Generally, Carbon dioxide are naturally emitted into the atmosphere during the global carbon cycle. Nevertheless, human activities have amplified atmospheric loadings in the course of daily combustion of fossil fuels and other emissions sources. “Natural sinks that remove carbon dioxide from the atmosphere (e.g., oceans, plants) help regulate carbon dioxide concentrations, but human activities can disturb these processes (e.g., deforestation) or enhance them". Similarly, Methane is induced by human activities like "coal mining, natural gas production and distribution, waste decomposition in landfills, and digestive processes in livestock and agriculture" (Intergovernmental Panel on Climate Change, 2013).

Nitrous oxide on the other hand, is released into the atmosphere through agricultural and industrial processes, in addition to "burning of solid waste and fossil fuels". In the course of daily household, commercial and industrial activities, several synthetic chemicals, are emitted into the atmosphere. These chemicals include "hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and other synthetic gases". "Many other gases are known to trap heat in the atmosphere. Examples include water vapor, which occurs naturally as part of the global water cycle, and ozone, which occurs naturally in the stratosphere and is found in the troposphere largely due to human activities" (U.S. Environmental Protection Agency, 2016).

2.2.2 Concept of Life Expectancy

U.K National Office of Statistics (2019) defined Life expectancy as"a statistical measure of the average time someone is expected to live, based on the year of their birth, current age and other demographic factors including their sex". In essence, life expectancy can be defined as the anticipated average age which individual member of a given population group would have attained at the point of death. Thus, a population with increasing life expectancy tend to live longer in "full health" than the one with lower expectancy index.

There is a strong link between good health and life expectancy because, as human live a healthier life, all other things being equal, the expected number of years they expect to live in "full health" will tend to increase (World Health Organization, 2019). Thus, the need to promote good health across all strata of life. This was the primary focus of the Sustainable Development Goals (SDG). For instance, Goal 3 of the SDG is “to ensure healthy living and promote well-being for all at all ages (Good Health)”.

Life expectancy is commonly measured using life expectancy at birth. This index can be well-defined as the average length of life of all persons born in a given year (Cohort life expectancy at birth) (Arthur & Steven, 2003). For instance, assuming that 5 people were born in 1970. If one dies at the age of 50years, the second at 52 years, the third, at 71 years, the fourth, at 65 years and the fifth, at 75 years, the average life expectancy is (50+52+71+65+75)/5= 62.6 years. This implies that on the average, individuals living in that country are likely to live up to 62.6 years before they die.

Life expectancy at birth can also be calculated “only for cohorts born many decades ago so that all their members have died. Period Life expectancy at birth is the mean length of life of a hypothetical cohort (all persons born in a given year) assumed to be exposed, from birth through death, to the mortality rates observed at a given year” (Shryock & Siegel, 1973).Life expectancy is a statistical tool that is often employed in the assessment and formulation of several relevant economic policies “that impact on everyday life”. A good instance of such policy is the determination of the National and State Pension age of workers as well as the design of appropriate health policy initiatives to promote good public health.

2.3 Stylized facts of environmental emissions in Nigeria

This section presents the stylized facts of the various environmental emissions in Nigeria, with particular reference to Carbon (iv) dioxide (CO_2), Methane emissions, Nitrous Oxide emissions and other greenhouse gases (HFC, PFC and SF6) emissions in Nigeria, which are "by-product emissions of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride"(Tohka& Amann, 2004).

2.3.1 Stylized facts of Carbon (iv) dioxide (CO2) emissions in Nigeria

The trend of Carbon (iv) dioxide (CO2) emissions in Nigeria was obtained from the Global Carbon Project (2020). The report captures CO2 emissions in Nigeria for a period of fifty (50) years spanning 1970 to 2019. From the report, the trend of Carbon (iv) dioxide (CO2) emissions in Nigeria has fluctuated over time with significant increases since 1970. For instance, annualCO2 emissions in Nigeria stood at 21.52million tonnes in 1970, but rose significantly to 62.24million tonnes in 1974.

It however declined to 48.22 million tonnes in 1978 after which it rose significantly to 70.19 million tonnes in 1979. As of 1983, CO_2 emissions in Nigeria has dropped to 59.71 million tonnes after which it rose to 73.19million tonnes in 1986. As of 1995, CO2 emissions in Nigeria has decreased to its all-time low of 33.42million tonnes, after which it increased significantly to 78.82 million tonnes in the year 2000. The report further revealed that Carbon (iv) dioxide emissions in Nigeria averaged 95.954 million tonnes between 2001 and 2010.

As of 2011 the figure as increased to129.57 million tonnes after which it declined to 113.54 million tonnes in 2015, but increased to 130.28 million tonnes in 2017. Carbon (iv) dioxide emissions in Nigeria however attained its all-time high of 140.03 million tonne in 2019, due to recent increase in general economic activities. These recent upsurges further expose the extent of the feeble renewable energy policy of the nation. From the trend analysis, most of the significant decreases were witnessed between 1989 and 1999, while there have been progressive increases since 2015.Figure 1 however reports the trends of Carbon (iv) dioxide emissions in Nigeria from 1970 to 2019.

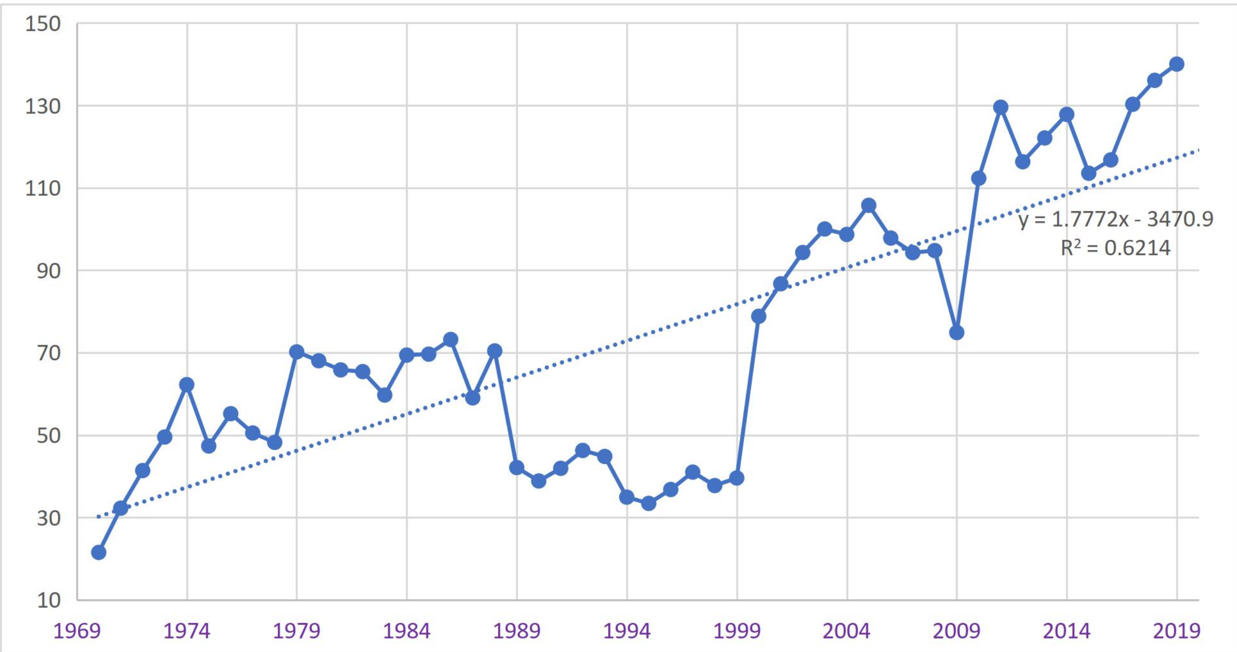

Figure 10: Carbon (iv) dioxide emissions in Nigeria (million tonnes) 1970-2019

Source: Author's computation from underlying data from the Global Carbon Project (2020).

2.3.2 Stylized facts of Methane emissions in Nigeria

The trend of Methane emissions in Nigeria was also generated from the data reported by the Global Carbon Project (2020). Similarly, the report captures Methane emissions in Nigeria for a period of fifty (50) years spanning 1970 to 2019. From the report, the trend of Methaneemissions in Nigeria has fluctuated over time with significant increases since 1970. Though, the periods 1970 to 1989 witnessed slow growth in the level of Methane emissions in the country, the later periods were characterized by instabilities with high growth trend. For instance, annual Methane emissions in Nigeria stood at 35.20million tonnes in 1970, but rose significantly to 59.25million tonnes in 1974.

It however declined to 51.40million tonnes in 1978 after which it rose significantly to 65.73million tonnes in 1979. As of 1983, methane emissions in Nigeria have dropped to 50.51 million tonnes after which it rose to 54.00million tonnes in 1986. As of 1994, methane emissions in Nigeria have increased significantly to 120.10million tonnes, after which it decreased significantly to 93.72million tonnes in the year 2000. The report further revealed that methane emissions in Nigeria averaged 100.975 million tonnes between 2001 and 2010. The figure has been rising progressively that, as of 2019,methane emissions in Nigeria reached its all-time high of 142.07million tonnes. From the trend analysis, most of the high methane emission experiences occurred from 1990 to 1994 as well as recent progressive increases especially from 2010 up to 2019. Figure 2 however reports the trends of Methane emissions in Nigeria from 1970 to 2019.

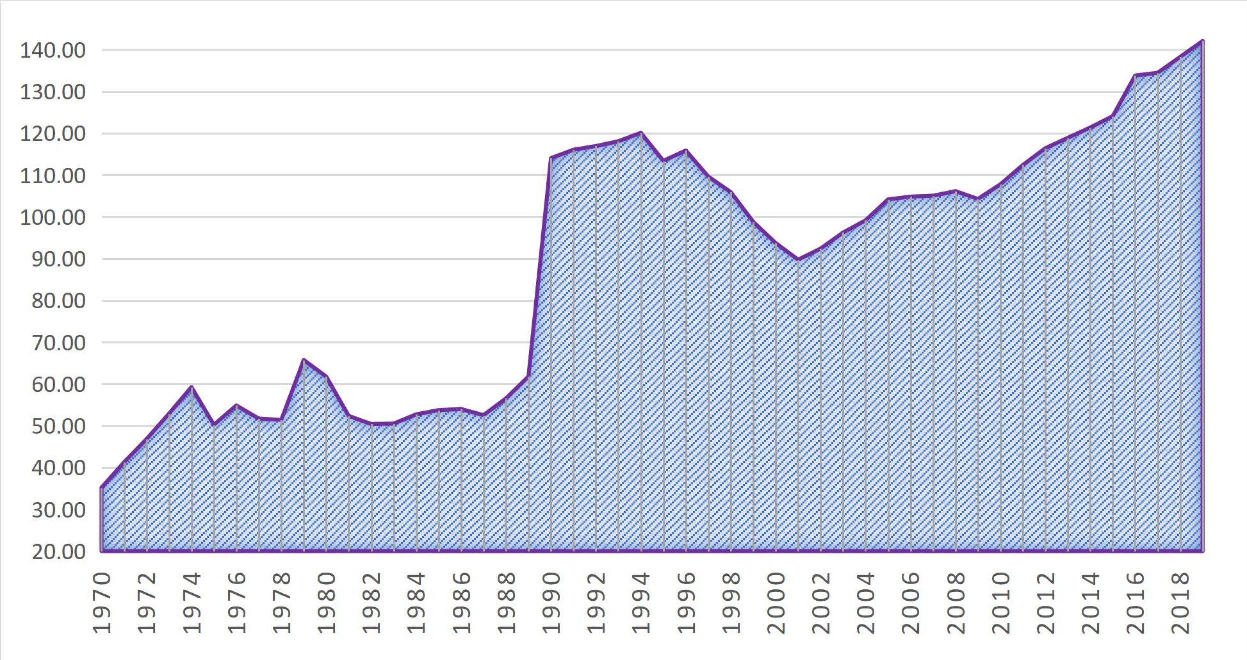

Figure 2: Methane emissions (million tonnes) in Nigeria (1970-2019)

Source: Author's computation from underlying data from the Global Carbon Project (2020).

2.3.3 Stylized facts of Nitrous Oxide emissions in Nigeria

Just like other environmental missions discussed above, the trend of Nitrous Oxide emissions in Nigeria was also produced from the data reported by the Global Carbon Project (2020). In the same way, the report captures Nitrous Oxide emissions in Nigeria for a period of fifty (50) years spanning 1970 to 2019. From the report, the trend of Nitrous Oxide emissions in Nigeria has been on a relatively stable rise over time compared to the remarkable volatilities in Carbon (iv) dioxide and methane emissions evaluated above. Though, there were small pockets of fluctuations inNitrous Oxide emissions in the country.

Essentially, Figure 3 reports the trends of Nitrous Oxide emissions in Nigeria from 1970 to 2019. From the graph, annual Nitrous Oxide emissions in Nigeria stood at

11.47million tonnes in 1970, but increased to 12.55million tonnes in 1973.Nitrous Oxide emissions however declined slightly to 12.39million tonnes in 1975 after which it rose to 16.24million tonnes in 1980. Between 1981 and 1987, Nitrous Oxide emissions in Nigeria alternated between 15.48million tonnes and 16.88 million tonnes yielding an average emission of about16.29million tonnes in that same period. between 1988 and 1995, Nitrous Oxide emissions averaged 20.79,while in year 2000, Nitrous Oxide emissions in Nigeria have increased to 28.94million tonnes after which it rose further to 30.86million tonnes in 2006.

As of 2009, Nitrous Oxide emissions in Nigeria have decreased significantly to 29.41million tonnes, after which it rose slightly to 31.71million tonnes in the year 2010. The report further revealed that Nitrous Oxide emissions in Nigeria averaged 35.55 million tonnes between 2011 and 2019. The figure has been rising progressively that, as of 2019, Nitrous Oxide emissions in Nigeria reached its all-time high of 38.82million tonnes. From the trend analysis, Nitrous Oxide emission were relatively stable with progressive growth from 2009 to 2019. Figure 3 however reports the trends of Nitrous Oxide emissions in Nigeria from 1970 to 2019.

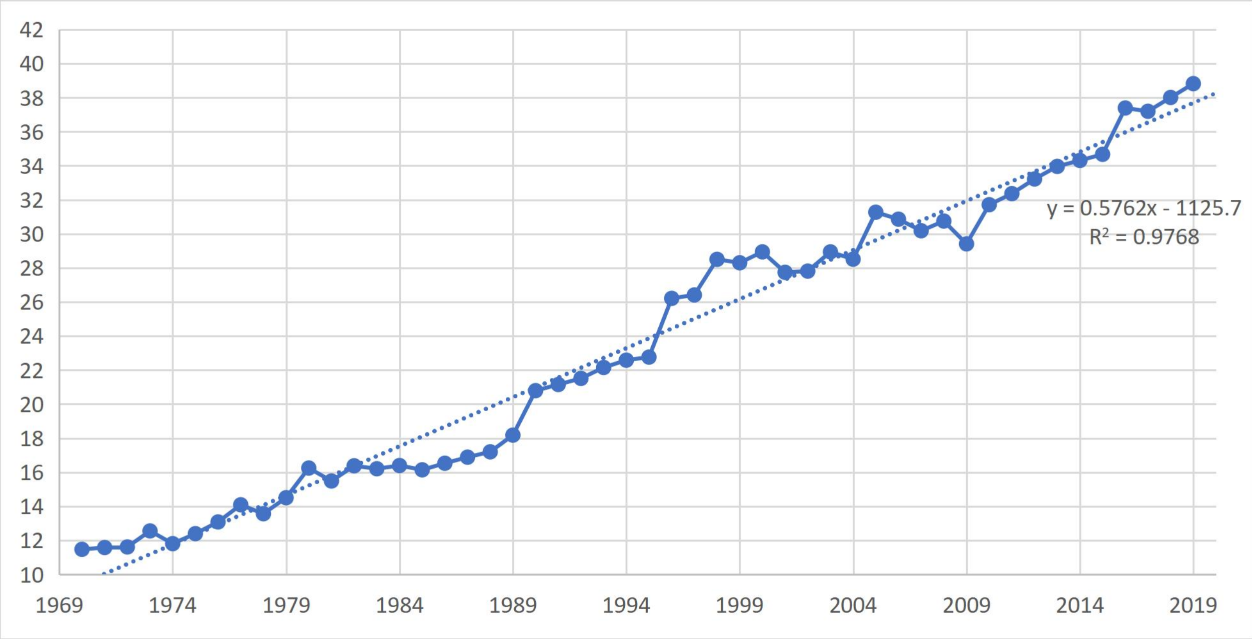

Figure 3: Nitrous Oxide emissions (million tonnes) in Nigeria (1970 -2019)

Source: Author's computation from underlying data from the Global Carbon Project (2020).

2.3.4 Stylized facts of Other Gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride) emissions in Nigeria

The trend of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions in Nigeria were produced from the data reported by the World Development Indicators of the World Bank (2020). Nevertheless, the report captures hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions in Nigeria for a period of forty-three (43) years spanning 1970 to 2012, while data for 2013 through 2019 were unavailable from similar sources.

From the report, the trend of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorideemissions in Nigeria were on the decrease from 1971 to 1981and relatively stable up to 1997 after which there were remarkable cases of volatilities in subsequent years. For instance, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride emissions in Nigeria rose remarkably from 3.46 million metric tons of CO2 equivalentin 1997to 152.07 million metric tons in 1998 and 174.38 million metric tons in 1999, after which it declined to 108.18 million metric tons in 2002 and 92.74million metric tons in 2004.

As of 2005, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorideemissions in Nigeria have attained their all-time high of 176.99million metric tons, but declined remarkable to 82.18million metric tons in the year 2009. The report further revealed that hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorideemissions in Nigeria averaged 88.92 million metric tons between 2010 and 2012. The figure however rose from 85.08 million metric tons in 2011 to 92.59 million metric tons in 2012. Figure 4 however reports the trends of hydrofluorocarbons, perfluorocarbons, and sulfur hexafluorideemissions in Nigeria from 1970 to 2012 as adapted from the World Development Indicators of the World Bank (2020).

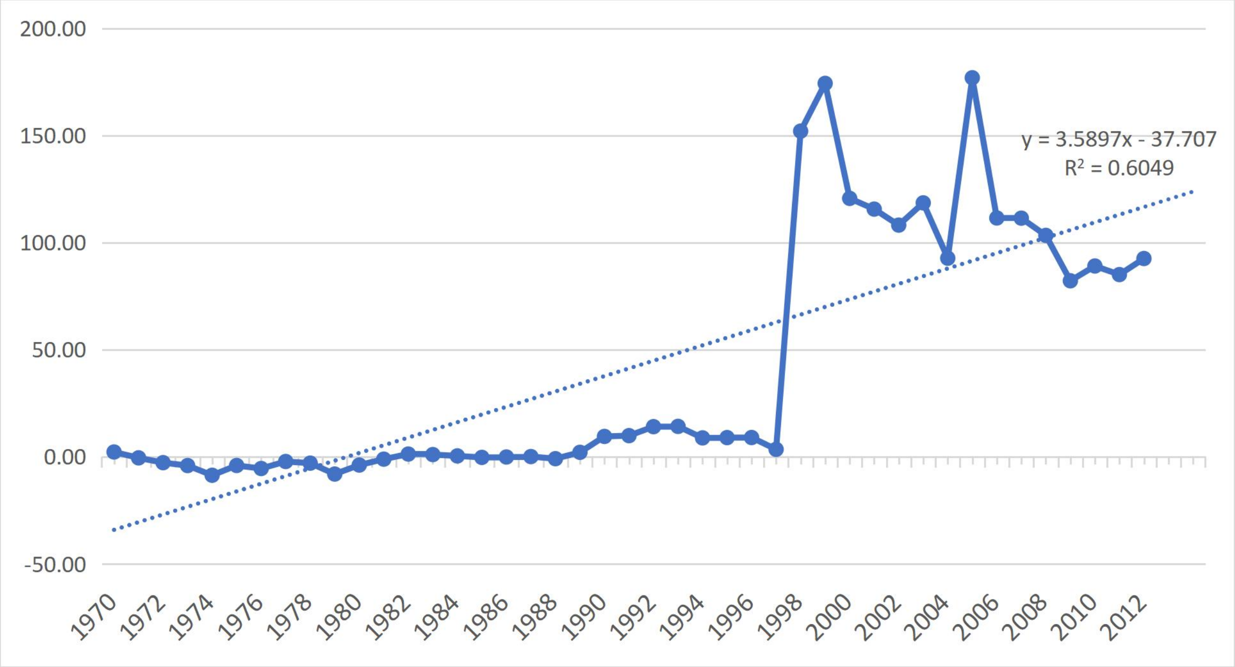

Figure 4: Other greenhouse gas emissions, HFC, PFC and SF6 (million metric tons of CO2 equivalent) (1970-2012)

Source: Author's computation from underlying data from World Development Indicators of the World Bank (2020).

2.4 Stylized facts of life expectancy at birth in Nigeria

The trend of life expectancy at birth in Nigeria were produced from the data reported by the United Nations World Population Prospects (2019). In addition, the report captures life expectancy at birth in Nigeria for a period of fifty (50) years spanning 1970 to 2019. From the report, the trend of life expectancy at birth in Nigeria has been on a progressive rise since 1970. Though, the growth was steep (rose faster) between 40.79 years in 1970 and 46.02 years in 1983,it however became flatter rose slowly)from46.02 years in 1983 to 46.94 years in 2003 with an average of 46.09 years in that period. It again became steep from 46.94 years in 2003 to 54.49 years in 2019.As of 2019, life expectancy at birthin Nigeria has increased to its all-time high of 54.5 years. Figure 5 however reports the trends of life expectancy at birth in Nigeria from 1970 to 2019 as adapted from the underlying data from United Nations World Population Prospects (2019).

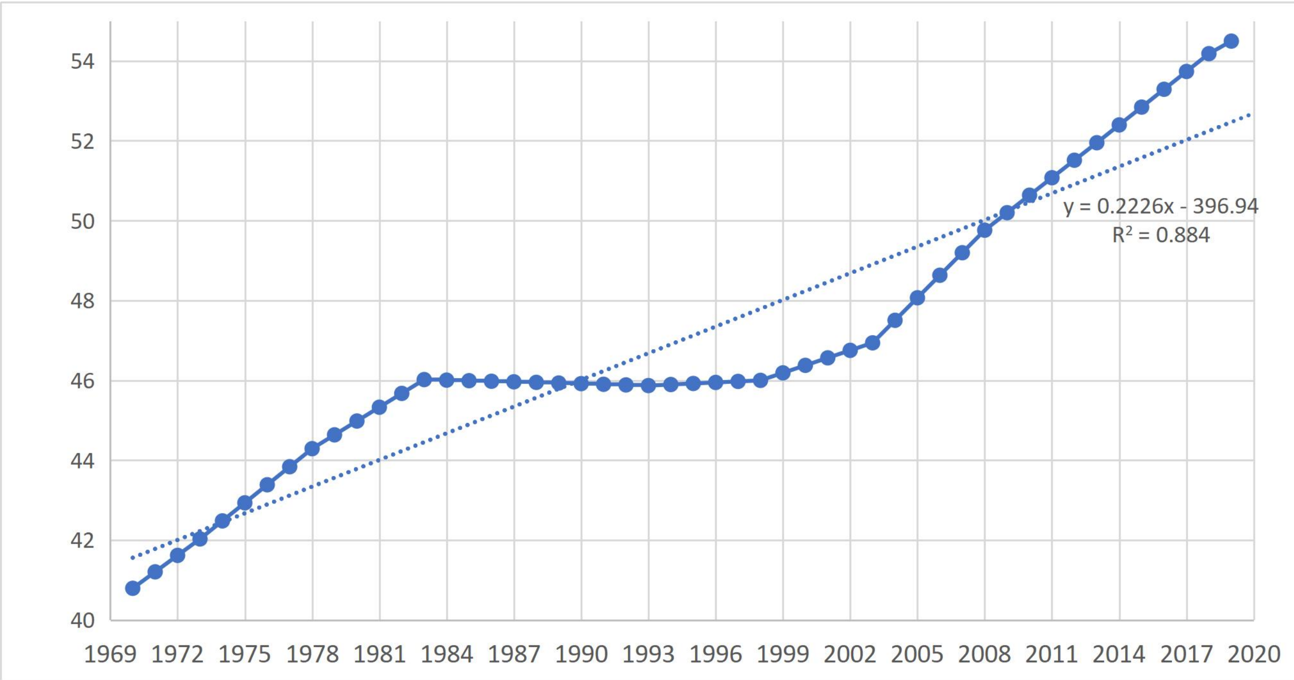

Figure 5: Life expectancy at birth, total (years) (1970- 2019)

Source: Author's computation from underlying data from United Nations World Population Prospects (2019).

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This chapter entails the review of a number of existing literatures that have theoretical, methodological and empirical relevance in relation to environmental emissions and life expectancy. Thus, the chapter establishes the various channels through which environmental emissions can influence the life span of individuals in a society. Specifically, this chapter discusses environmental theories in relation to life expectancy. The last segment of the chapter will be devoted to the analysis of empirical gaps stemming from the reviewed literature and further explains how the identified gaps will be bridged in the course of this present study.

3.2 Theoretical Literature

A number of theoretical expositions have been offered in unveiling the interaction between the ecosystem and the various emission gases and how these emissions can impact on human lives. In what follows, this study attempts to explain the most relevant theories, which establish the various channels through which increasing incidences of emissions can translate into unsustainable ecosystem capable of deteriorating human health and further cause a significant reduction in human lifespan.

Earlier studies have presented a number of avenues for gaining deep insights into the various environmental theories. To that effect, this section attempts to explicate some of these theories as they relate to environmental emissions and life expectancy. Among the notable environmental emissions related theories include; the shareholders' theory, Agency theory, and the stewardship theory. These theories will be discussed in succession as the study advances.

3.2.1 Theory of Environmentally Responsible Behaviour (ERB)

The **theory of environmentally responsible behaviour** was advanced in the earlier work of Hines, Hungerford and Tomera in 1987 (Hines, Hungerford & Tomera, 1987) who submit that when individuals possess good intention, they will always act in an environmentally responsible way. The implication is that, when people are conscious of the adversative impact of environmental pollutions, they will demonstrate good intentions that will make them to act in a way to protect and preserve the natural environment, rather than carrying out unwholesome activities that have the tendency to hurt the ecosystem (Hsu & Roth, 1998; Kollmuss& Agyeman, 2002; Steg &Vlek, 2009).

The key assumption here is that, people are fully aware of the negative effects of environmental pollutions, hence try to avoid those negative effect by ensuring that they protect the natural environment. The intention to always act with a view to protecting the environment makes these individuals environmentally responsible compared to other individuals who always carry out activities with the potential to cause detrimental effects on the ecosystem (Chiu, Lee, & Chen, 2014).Thus, rather than engaging in environmentally hostile activities such as combustion of solid fuels and poor environmental waste management, individuals with good intentions will act by planting trees, minimise environmental hazards and even champion public campaigns that will help in promoting environmental sustainability.

The Responsible Environmental Behaviour Model of captures some principal variables that make individuals of groups environmentally responsible. The key variables include “intention to act, locus of control (an internalized sense of personal control over the events in one’s own life), attitudes, sense of personal responsibility, and knowledge which often determine whether a person would adopt a behaviour or not” (Osbaldiston& Sheldon, 2003; Lee-Kelley, 2006; Ojedokun, 2011).

Figure 6illustrates the interactions within the model of environmentally responsible behaviour. This model explains that knowledge is paramount for exercising self-control as well as exhibition of right attitudinal dispositions. Knowledge about the environmental emissions effects will lead to both attitudes and personal responsibility (Su, Hsu & Boostrom Jr, 2020). Both attitude and personal responsibility will influence the individuals’ ability to demonstrate good intentions that will make them behave in a more environmentally responsible way. Figure 6illustrates the model of environmentally responsible behaviour below.

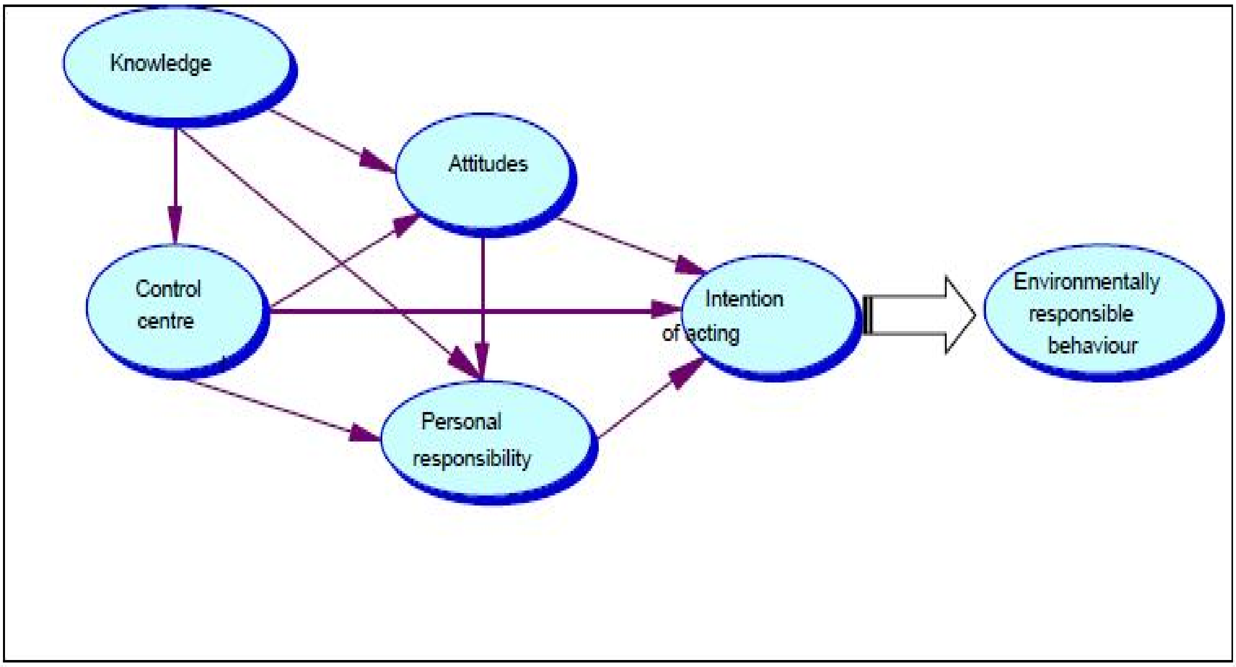

Figure 6: The model of environmentally responsible behaviour

Source: Adapted from Hsu and Roth (1998).

The model of environmentally responsible behaviour has however been challenged on certain grounds. For instance, Akintunde (2017)argued that people do not always act in favour of the ecosystem despite the enforcement of various environmental regulations. Specifically, when analyzing waste management procedures, neither the intention to act, an adopted sense of personal control, attitudes, sense of personal responsibility, nor knowledge is responsible for the present behaviours or adequate to trigger peoples' behaviours to act in an environmentally responsible manner.

This can be best explained by the instances of people who accumulateor "pile up their waste materials in the middle of the streets in large cities like Ibadan, Port Harcourt, Jos etc., despite regulations from waste management authorities, prohibiting these acts" (Akintunde, 2017). These individuals are very much aware of the detrimental effects of their actions to the ecosystem as well as the legal implication of such actions, yet perpetuate such immoral acts “at odd hours when law enforcement agencies are not available, others are influenced to indiscriminately dump these waste materials because they see others doing so” (Akintunde, 2017).

Despite such ethically unacceptable behaviours, there are other individuals whostill practice the act of decent waste disposal. These sets of individuals may be fully aware of their actions, yet, some choose to act in an indecent way, thus causing harm to the ecosystem. Consequently, the major argument against the model is that, knowledge is not adequate for individuals to act in an environmentally responsible way.

3.2.2 The Environmental Citizenship Model

The Environmental Citizenship Model is another environmental model advanced in the work of Hungerford and Volk in 1990 (Hungerford & Volk, 1990). The basis of the Environmental citizenship is the need for every individual in the society to take responsibility for the manner with which they interrelate with the ecosystem (Raineri & Paillé, 2016). To maintain excellent environmental citizenship, the model proposed that individuals should keep waste down to a minimum in their home through effective practicing of “triple R” of waste reduction, re-use and recycling as this is hoped to reduce daily environmental emission incidences.

The environmental citizenship model of Hungerford Volk however presents three phases of enlightening participation starting from first introduction (entry) to actual participation (enablement). The assumption of the model is that each phase is characterized by certain degree of knowledge and attitude that propels individuals to act in their quest to becoming good environmental citizens.

Hungerford and Tomera with the aid of the environmental citizenship model, assembled the key variables that often determine the ability of the individuals to take relevant action into three groupings, represented in Figure 7 below. The first stage in the model is the Entry-level variables which covers general enlightenment to and knowledge of the environment, while the second phase comprises ownership variables which helps individuals to gain thorough knowledge, personal commitment, and resolve. Similarly, the third stage captures the Empowerment variables which helps the individuals to exhibit and develop “action skills, locus of control, and intention to act” (Akintunde, 2017).

The Environmental Citizenship Model still remains one of the important theories of environment especially following the quest for environmental sustainability, which is the crux of The Sustainable Development Goal 17.The model will enable people to act by going to length of possessing or developing new skills necessary for the promotion of the ecosystem, while mitigating the adversative effect of climate change. the theory is useful as it relates to both private environmental consumers as well as corporate citizens that interact with the natural environment on a daily basis.

This will serve as a caution for them to act in a manner to reduce environmental wastes while thriving for renewable energy channels. Environmental sustainability is everybody’s responsibility. Since on one can take responsibility when he or she is no more, the model calls for every citizen to take full responsibility now either through awareness creation, personal development or to the point of full participation.

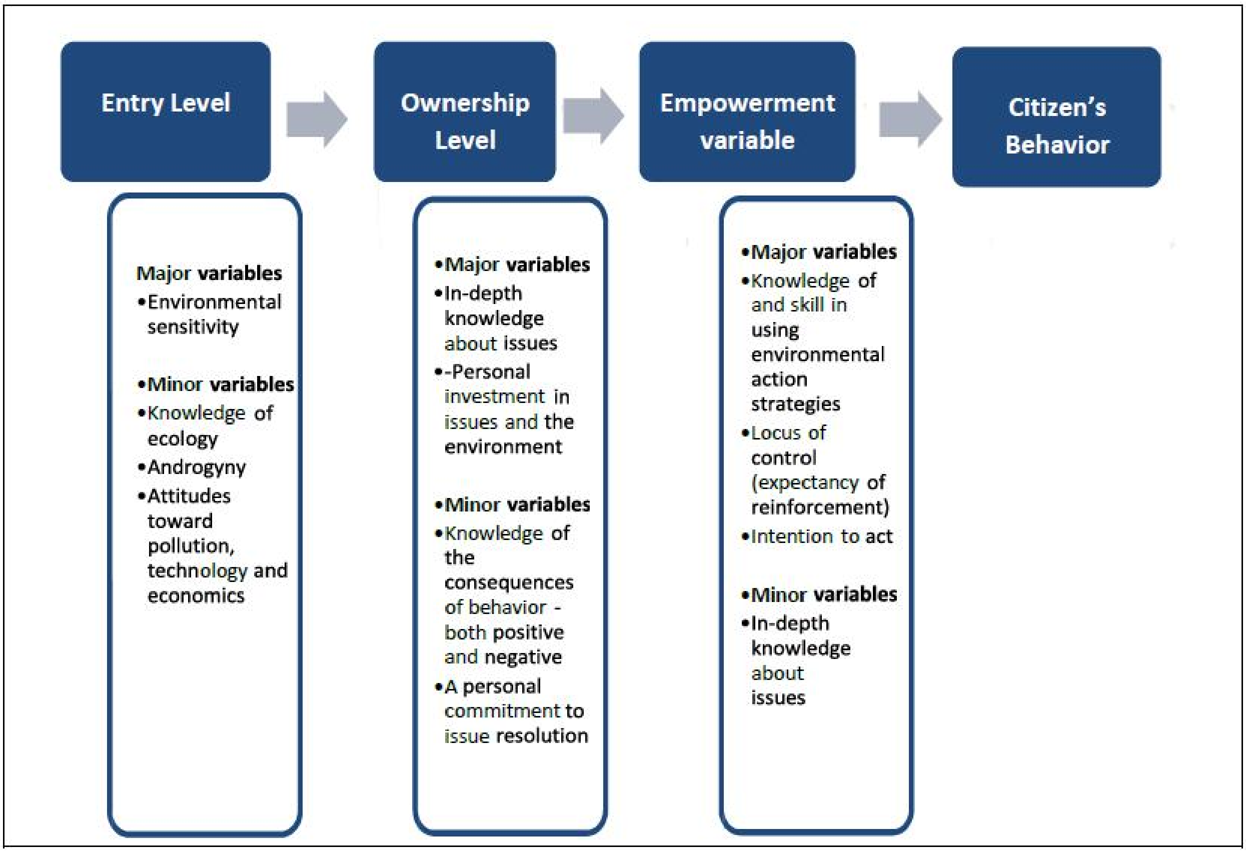

Figure 7: The Environmental Citizenship Model

Source: Hungerford and Volk (1990).

3.2.3 Human-Environment interaction model

The Human-Environment interaction model is a theoretical postulation attributed to the work of Hammond in 1995 (Stern, 1999). This model demonstrates four mechanisms through which human constantly interrelate with the natural environment and further reveals the extent to which human engage in environmentally unhealthy activities which in turn result in exert reverse causality on man who depends on the products of the environment for daily survival (Zhang, Qin, Li, Zou, & Ding, 2020; Carleton & Collard, 2020; Luzzini, 2020; Spano, Giannico, Elia, Bosco, Lafortezza, &Sanesi, 2020; Arora, Giuliani & Curtin, 2020). The four dimensions of Human-Environment interaction include source, sink, life-support and human welfare.

In the case of source, the theory posits that, individuals obtain all forms of "minerals, energy, food, fibers, and other natural resources that are daily utilized in the economy". These activities of man have the tendency to deplete these natural resources or degrade the biological structures like land on which both agricultural activities and manufacturing processes are carried out on regular basis.

In the case of sink, the theory explains that "natural resources are transformed by industrial activity into products (such as pesticides) and energy services that are used or disseminated and ultimately discarded or dissipated, thus creating pollution and wastes that (unless recycled) flow back into the environment". Thus, the release of harmful substances into the ecosystem has the tendency to reduce human lifespan due to the deteriorating effect of these harmful elements in the atmosphere.

The third channel through which human constantly interact with the environment is Life support. Sciences explain that there is a constant exchange of gases for daily respiration between plants and animals including humans. While humans depend on plants for oxygen, plants in turn depend on humans for carbon dioxide for respiration. This form of life support is made possible by the ecosystem where the plants are grown. However, the persistent war against forestation through indiscriminate cutting of trees by mankind poses a serious life-threatening risk on human survival.

The fourth channel of constant interaction between humans and the environment is the assessment of the impact of the environment on human well-being. The basic assumption of this model in relation to the subject of this research, is that several elements such as Poisoned air and water as well as contaminated food substances exert harmful effects on human health and well-being directly. The long run impact of these elements is the reduction of the expected lifespan of humans, thus, a decline in life expectancy.

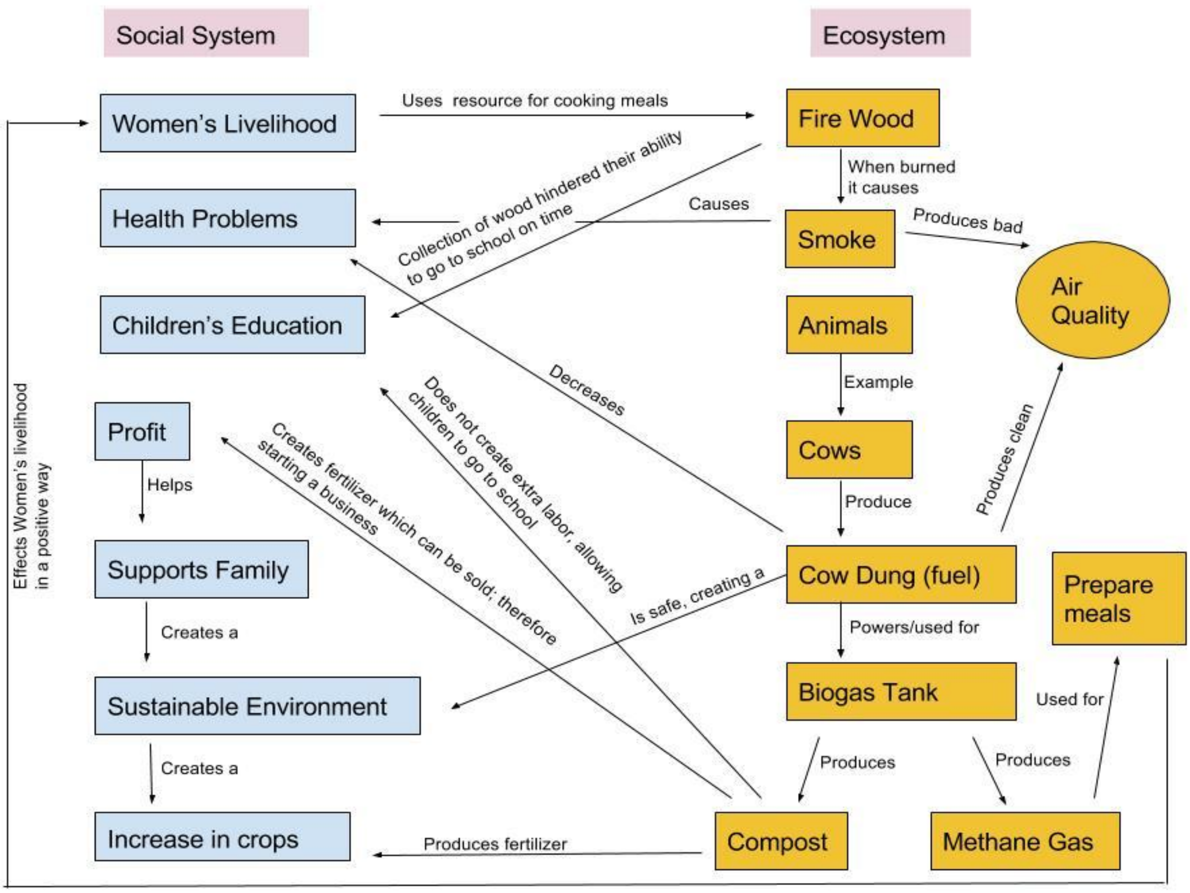

Figure 811: Human-Environment interaction model

Source: https://geog030.dutton.psu.edu/2016/01/26/module-2-human-environment-sytems/

3.3 Methodological Review

The empirical revelations relating to the effects of environmental emissions on life expectancy presented in the next section have been mixed. These empirical results differ with the research methodology employed by each study. It therefore follows that the realization of quality estimates requires the use of suitable analytical procedure in accomplishing the key objectives of the study. In this section, the study offers a comparative review of the various research methodologies adopted by previous studies that had bearing with the subject matter.

Specifically, the study of Monsef and Mehrjardi (2015) employed the panel least squares, while the study of Ebenstein, Fan, Greenstone, He, Yin and Zhou (2015) employed a "first-difference Least Squares regression model" in carrying out the estimations in the period of assessments. Also, the study of Ali and Audi (2016) employed the "Auto-Regressive Distributed Lag (ARDL) for exploring the co-integration among the variables of the model", while the study of Fann, Kim, Olives and Sheppard (2017) adopted the "log-linear and nonlinear concentration–response model".

It was further established that the study of Ebenstein, Fan, Greenstone, He and Zhou (2017) adopted a "regression discontinuity design based on parametric and nonparametric estimation methods", while the study of Amuka, Asogwa, Ugwuanyi, Omeje and Onyechi (2018) adopted "the ordinary least square (OLS) technique". Similarly, "the study of Nkalu and Edeme (2019) adopted generalized autoregressive conditional heteroscedasticity (GARCH) model in estimating the total number of 58 (years) observations to ensure robustness in the estimation results".

The study of Sarkodie, Strezov, Jiang and Evans (2019) further adopted the "generalized least squares (GLS) random-effects model estimation with first-order autoregressive [AR(1)] disturbance across 54 countries", while the study of Hill, Jorgenson, Ore, Balistreri and Clark (2019) adopted the "two-way fixed-effects panel regression techniques to analyse longitudinal data for 49 US states and the District of Columbia". In similar finding, the study of Cheng, Li, Li, and Tang (2019) adopted "the air pollutant emission simulation model (GAINS) with 3 versions and CMIP5", while "this study of Agbanike, Nwani, Uwazie, Uma, Anochiwa, Igberi and Ogbonnaya (2019) used the autoregressive distributed lag (ARDL) bounds testing approach to cointegration to examine the dynamic relationship between environmental pollution and life expectancy in Nigeria".

The study of Igbinedion (2019) adopted the "Johansen co-integration and error correction modelling" while, the study of Majeed and Ozturk (2020) employed the "fixed-effects approach based on Hausman test, two-stage least squares (2SLS) and system-generalized method of moments (SGMM)". The study of Shah, Wang, Ullah, Akbar, Khan and Bah (2020) engaged the "nonlinear autoregressive distributed lag model (ARDL) approach for the empirical assessment", while the study of Poças, Soukiazis and Antunes (2020) also employed a panel Least Squares method for analyzing the data set. Furthermore, panel corrected standard errors (PCSE) and feasible general least square (FGLS) estimates were engaged in the study of Rahman, Rana and Khanam (2020) for investigating the effect of environmental degradation on life expectancy in the period of assessment. The above methods were further complemented by Pairwise Granger causality tests.

It was also established that “the study of Matthew, Owolabi, Osabohien, Urhie, Ogunbiyi, Olawande and Daramola (2020) employed the two-stage least squares econometric technique”, while the study of Khanzadi, Jaliliyan, Moradi and Heidariyan (2020) employed the “Generalized Method of Moments”. “The Autoregressive Distributed Lag (ARDL) model was applied in the study of Osabohien, Aderemi, Akindele and Okoh (2020) to examine how energy consumption impact on life expectancy in Nigeria”, while the study of Murthy, Shaari, Mariadas and Abidin (2021) employed the panel ARDL method. Finally, the reviewed literature revealed that the study of Rjoub, Odugbesan, Adebayo and Wong (2021) adopted the “Bayer–Hanck cointegration test, wavelet coherence, Fourier Toda–Yamamoto, and Breitung–Candelon frequency-domain spectral causality tests”.

3.4 Empirical review

Granting the fact that a very few earlier studies have been conducted in the context of Nigeria on the subject matter, the literature is replete with a number of previous empirical studies conducted globally. Thus, this section presents the various findings of earlier empirical works carried out in different countries. For all intents and purposes, the section reports the empirical outcomes of the studies carried out in Nigeria and other countries. The section further reveals the various proxies employed by these studies in their individual modelling contexts.

3.4.1 Previous empirical studies in Nigeria

As mentioned earlier, a very few studies have been conducted in the context of Nigeria on the effects of environmental emissions on life expectancy. Amon these few studies include Amuka, Asogwa, Ugwuanyi, Omeje and Onyechi (2018), who examined "the link between climate change and life expectancy in a developing country with specific emphasis on greenhouse gas (CO2) emission in Nigeria" using quarterly data set spanning the period from 1995 to 2013.The empirical results revealed inter alia that carbon dioxide emission exhibits a statistically insignificant positive effect on life expectancy, suggesting that CO2 emissions have not caused a significant decline in the average number of years of Nigerian life in the period of assessments.

Nkalu and Edeme (2019) further explored the empirical link between environmental hazards and life expectancy in Nigeria for the period 1960 to 2017. From the empirical analysis, the result indicated that "environmental hazards in terms of carbon dioxide (CO2) emission from solid fuel consumption exerted a statistically significant negative influence on life expectancy (LEX) by 1 month and 3 weeks".

Also, Agbanike, Nwani, Uwazie, Uma, Anochiwa, Igberi and Ogbonnaya (2019) explored "the linkage between oil, environmental pollution and life expectancy in Nigeria" using annual data set for the period spanning from 1971 to 2014.The empirical outcomes of the study established among other things "that while oil export provides the revenue required to improve life expectancy in the country, it also generates economic conditions that accelerate environmental pollution (carbon dioxide) emissions which further leads to a significant deterioration in life expectancy in Nigeria in the long run".

In similar observation, Igbinedion (2019) on the other hand examined the link between environmental emissions and life expectancy with further evidence from Nigeria with the aid of yearly data set covering the period 1990 to 2016. The study employed per capita carbon dioxide as the independent variable representing environmental emissions, while life expectancy was utilized as the explained variable. The empirical outcomes of the study however reveled among other things that "environmental emission exert significant effect on life expectancy at birth in Nigeria". Osabohien, Aderemi, Akindele and Okoh (2020) further investigated "the link between carbon emissions and life expectancy in the context of Nigeria for the period 1980 to 2017".The empirical outcomes of the study established among other things "that carbon emissions are significant and negatively affect life expectancy".

Lastly, Murthy, Shaari, Mariadas and Abidin (2021) explored the "relationships between CO2 emissions, economic growth and life expectancy in the D-8 countries (Malaysia, Indonesia, Bangladesh, Nigeria, Egypt, Iran, Pakistan, and Turkey) from 1992 to 2017". From the empirical results, it was established that "economic growth, population growth and health expenditure significantly and positively affect life expectancy", while "CO2 emissions exerted a significant negative effect on life expectancy" in the assessment period. This further suggests that life expectancy is significantly influenced by emissions origination from Carbon (iv) Oxide.

3.4.2 Previous empirical studies in other countries

Among the earlier studies conducted in other countries to investigate the effects of environmental emissions on life expectancy, Chen, Lin and Chan (2014) explored "the impact of petrochemical industries activities on life expectancy and per capita income in Taiwan using 11-year longitudinal experimental survey for the period spanning 1999 to 2010. The result from the experimental survey showed that "residents of the industrialized county had lesser increases in life expectancy over time than did residents of a similar but less-industrialized county, with difference means ranging from 0.89 years ($p < 0.05$) to 1.62 years ($p < 0.001$) at different stages. Male residents were more vulnerable to the effects of industrialization".

Monsef and Mehrjardi (2015) investigated the determinants of life expectancy with the aid of a panel of 136 countries for the period spanning 2002 to 2010. The dependent variable used in the study was life expectancy, while the independent variables include some selected economic, social and environmental fundamentals. From the empirical results the study established that "unemployment and inflation are the main economic factors that influence the life expectancy negatively, while gross capital formation and gross national income exerted positive effects on life expectancy". From the socio-environmental perspective, the study established that rural-urban drift is the principal variable that influences mortality among the 136 countries under assessment.

Ebenstein, Fan, Greenstone, He, Yin and Zhou (2015) also assessed the nexus between "Growth, pollution, and life expectancy with evidence from China for the period spanning 1991 to 201. The empirical evidence revealed the presence of "robust positive association between city-level GDP and life expectancy' while a negative association between city-level particulate air pollution exposure and life expectancy was further established".

Ali and Audi (2016) explored the "impact of income inequality, environmental degradation and globalization on life expectancy in Pakistan with the aid of time series data for the period 1980 to 2015". For examining the causal relationship Granger Causality test is used. From the empirical outcomes, it was established that "income inequality and environmental degradation have negative and significant impact on life expectancy in Pakistan. The results of Granger causality show that there is unidirectional causality running from all independent variables to dependent variable".

Fann, Kim, Olives and Sheppard (2017) "estimated changes in life expectancy and adult mortality resulting from declining PM 2.5 exposures in the contiguous United States for the period 1980 to 2010". It was established that from the period 1980 to 2010, "population-weighted PM2.5 exposures fell by about half, while the estimated number of excess deaths also declined by about a third". The state-specific analyses revealed that "the States of California, Virginia, New Jersey, and Georgia had some of the largest estimated reductions in PM2.5attributable deaths".

Ebenstein, Fan, Greenstone, He and Zhou (2017) explored "the impact of sustained exposure to air pollution on life expectancy from a quasi-experimental variation in PM_{10} generated by China's Huai River Policy, which provides free or heavily subsidized coal for indoor heating during the winter to cities North of the Huai River but not to those to the south". The result of the study revealed "that a

10-µg/m^3 increase in airborne particulate matter [particulate matter smaller than 10 µm (PM_{10})] reduces life expectancy by 0.64 years (95% confidence interval = 0.21–1.07)".

Sarkodie, Strezov, Jiang and Evans (2019) explored the "proximate determinants of ambient air pollution, mortality and life expectancy in Europe, Central Asia, Australia, Canada and the US by employing time series data spanning 2000 to 2016" the explanatory variables in the estimation model were"urban population, total pollution, energy consumption, GDP per capita, life expectancy, mortality rate and industrial PM2.5 emissions" while life expectancy was the dependent variable. The empirical outcomes of the study revealed *inter alia*, "that an increase in industrial PM2.5 emissions per capita by 1% decreased life expectancy by 0.004% (95% CI)". The implication of this finding is that "ambient air pollution contributes significantly in reducing life expectancy and increasing mortality".

Hill, Jorgenson, Ore, Balistreri and Clark (2019) explored the nexus between air quality and life expectancy in the United States with special consideration to the moderating effect of income inequality for the period 2000 to 2010. The empirical result revealed that "the association between state $PM_{2.5}$ levels and average life expectancy intensifies in states with higher levels of income inequality. More specifically, $PM_{2.5}$ levels are more detrimental to population life expectancy in states where a higher percentage of income is concentrated in the top 10% of the state income distribution".

Cheng, Li, Li, and Tang (2019) explored the "response of global air pollutant emissions to climate change and its potential effects on human life expectancy loss in China from 1970 to 2010. It was however established that “the total global emission of major air pollutants increased 1.32 times during 1970–2010”. Similarly, the results indicated that “Air pollutant emissions will increase 2.89% and 4.11% in China and developed countries when the scenario of only maximum technically feasible reductions is performed (V4a) during 2020–2050”.

Balakrishnan, Dey, Gupta, Dhaliwal, Brauer, Cohen and Dandona (2019) explored “the impact of air pollution on deaths, disease burden, and life expectancy across the states of India in the context of the Global Burden of Disease Study 2017”. The explanatory variables captured in the stud y include“ambient particulate matter pollution and household air pollution”. It was revealed that “12·5% of the total deaths were attributable to air pollution, including 0·67 million (0·55–0·79) from ambient particulate matter pollution and 0·48 million (0·39–0·58) from household air pollution”.

Majeed and Ozturk (2020) explored the link between “environmental degradation and population health outcomes from the perspective of a global panel data analysis with specific emphasis on 180 nations. The study utilized annual data set spanning1990 to 2016. Similarly, “life expectancy and infant mortality were utilized as proxies for population health”, while CO2 emissions was used to capture environmental degradation. From the outcome of the analysis, it was established that “environmental degradation negatively influences population health outcomes”. The implication is that increasing level of environmental degradation is linked with declining life expectancy as well as rising cases of infant mortality in the context of the 180 countries under investigations.

Shah, Wang, Ullah, Akbar, Khan and Bah(2020) investigated the possibility of "environment quality and public spending on environment to influence life expectancy in the context of China" using quarterly data set spanning1999Q1 to 2017Q4. From the empirical outcomes, it was established that there exists "a long-run relationship between environmental quality, public spending on the environment and life expectancy in China". In addition, it was reported that the response of life expectancy to "both positive and negative shocks of environmental quality were mixed both in the long- and short-run". The empirical outcomes revealed that increasing spending on environmental quality promotes life expectancy. In the short run, it was established that population growth rate significantly influences life expectancy in China during the period of investigation.

Poças, Soukiazis and Antunes(2020) explored the "factors explaining life expectancy at age 65 from the angle of a panel data approach applied to 20 European Union Countries for the period spanning 1990 to 2016". The study utilized life expectancy at age 65 as the dependent variable, while "population structure, health resources, lifestyles and environment were the independent variables captured in the study. The result of the analysis revealed that "risky lifestyles and air pollution have a significant negative impact on health" in the period of assessment.

Rahman, Rana and Khanam (2020) further explored the "determinants of life expectancy in most polluted countries with specific emphasis on the effect of environmental degradation on life expectancy in the context of 31 world's most polluted countries. The study employed yearly data set spanning the period 2000 to 2017. However, the empirical outcomes of the study revealed the presence of negative effect of environmental degradation on life expectancy, while "health expenditure, clean water and improved sanitation exerted a positive effect on life expectancy for all the 31 countries investigated in the period. in addition, "the causality test results reveal one-way causality from carbon emissions to life expectancy and bidirectional causalities between drinking water and life expectancy, and sanitation and life expectancy".

Matthew, Owolabi, Osabohien, Urhie, Ogunbiyi, Olawande and Daramola(2020) "examined effect of carbon emissions (independent variable) on agricultural output and life expectancy (explained variable) in West Africa using data that spanned the period between 2000 and 2018". The empirical outcome of the study stashed that "carbon emissions harmfully impact on agricultural output, but serves as a boost to life expectancy in the context of West Africa".

Khanzadi, Jaliliyan, Moradi and Heidariyan (2020) explored the "effects of environment quality improvement on life expectancy in Iran using annual data for 30 provinces for the period spanning 2003 to 2014. Th study utilized carbon dioxide emissions as a proxy for environment quality which served as the independent variable, while life expectancy was used as the dependent variable in the study**. F**rom the empirical results, it was established **that** "environmental pollution exhibits a significant negative impact on life expectancy, suggesting that increasing CO_2 emissions reduced life expectancy in Iran provinces".

Jorgenson, Thombs, Clark, Givens, Hill, Huang and Fitzgerald (2021) "estimated cross-national longitudinal models to test whether the negative relationship between life expectancy and PM2.5 concentration is larger in nations with higher levels of income inequality". "PM2. 5 refers to particles that have diameter less than 2.5 micrometres (more than 100 times thinner than a human hair) and remain suspended for longer. These particles are formed as a result of burning fuel and chemical reactions that take place in the atmosphere."

Thus, average life expectancy at birth was employed as the dependent variable, while the independent variables were "PM2.5 concentration, income inequality, and the two-way interaction between them". The empirical outcomes of the study revealed the presence of a "negative relationship between life expectancy and PM2.5 concentration and this was larger in nations with higher levels of income inequality". It was further noted that "the reductions in predicted life expectancy are substantial when both PM2.5 concentration and income inequality are high". This implies that increases in both PM2.5 concentration and income inequality lead to declining life expectancy.

Rjoub, Odugbesan, Adebayo and Wong (2021) explored "the causal relationships among carbon emissions, economic growth, and life expectancy in Turkey" with aid of long time-series data for the period spanning 1960 to 2018". The explanatory variables utilized in the study include "carbon emissions and economic growth, while the explained variable was life expectancy. The empirical results of the study established the presence of "a positive co-movement between life expectancy and CO_2". The summary of the reviewed literature is presented in the Tables below.

Table 1: Summary of Reviewed Literature

S/N	AUTHOR & DATE	PERIOD	TITLE	COVERAGE AREA	METHODOLOGY	DEPENDENT VARIABLE	INDEPENDENT VARIABLE	RESULT/REMARK
1	Chen, Lin and Chan (2014)	1999 to 2010.	“the impact of petrochemical industries activities on life expectancy and per capita income	Taiwan	Descriptive statistics	life expectancy	CO2 emissions	“residents of the industrialized county had lesser increases in life expectancy over time than did residents of a similar but less-industrialized county
2	Monsef and Mehrjardi (2015)	2002 to 2010	"determinants of life expectancy"	136 countries	panel least squares	life expectancy	economic, social and environmental fundamentals	From the socio-environmental perspective, the study established that rural-urban drift is the principal variable that influences mortality among the 136 countries under assessment.

3	Ebenstein, Fan, Greenstone , He, Yin and Zhou (2015)	1991 to 2010	“Growth, pollution, and life expectancy"	China	“first-difference Least Squares regression model”	life expectancy	GDP and particulate air pollution exposure	"A negative association between particulate air pollution exposure and life expectancy was established”.
4	Ali and Audi (2016)	1980 to 2015	“impact of income inequality, environmenta l degradation and globalization on life expectancy in Pakistan"	Pakistan	“Auto-Regressive Distributed Lag (ARDL) Approach"	life expectancy	income inequality and CO2 emissions	“income inequality and environmental degradation have negative and significant impact on life expectancy in Pakistan.
5	Fann, Kim, Olives and Sheppard (2017)	1980 to 2010	“Changes in life expectancy and adult mortality resulting from declining PM 2.5 exposures in the contiguous United	United States	“log-linear and nonlinear concentration–response model”	life expectancy	particulate air pollution exposure	“population-weighted PM2.5 expo sures fell by about half, while the estimated number of excess deaths also declined by about a third”.

			States”					
6	Ebenstein, Fan, Greenstone, He and Zhou (2017)	not stated	“the impact of sustained exposure to air pollution on life expectancy from a quasi-experimental variation in PM10 generated by China’s Huai River Policy	China	“regression discontinuity design"	life expectancy	exposure to air pollution	“a 10-μg/m^3 increase in airborne particulate matter [particulate matter smaller than 10 μm (PM_{10})] reduces life expectancy by 0.64 years (95% confidence interval = 0.21–1.07)”.
7	Amuka, Asogwa, Ugwuanyi, Omeje and Onyechi (2018)	1995 to 2013	“the link between climate change and life expectancy in a developing	Nigeria	“the ordinary least square (OLS) technique”	life expectancy	greenhouse gas (CO2) emission	carbon dioxide emission exhibits a statistically insignificant positive effect on life expectancy

			country"					
8	Nkalu and Edeme (2019)	1960 to 2017	"environmental hazards and life expectancy in Nigeria"	Nigeria	generalized autoregressive conditional heteroscedasticity (GARCH) model	life expectancy	CO2 emissions	"environmental hazards in terms of carbon dioxide (CO2) emission from solid fuel consumption exerted a statistically significant negative influence on life expectancy (LEX) by 1 month and 3 weeks"
9	Sarkodie, Strezov, Jiang and Evans (2019)	2000 to 2016	"proximate determinants of ambient air pollution, mortality and life expectancy"	Europe, Central Asia, Australia, Canada and the US	"generalized least squares (GLS) random-effects model estimation with first-order autoregressive [AR(1)] disturbance"	life expectancy	"urban population, total pollution, energy consumption, GDP per capita, life expectancy, mortality rate and industrial PM2.5 emissions"	"ambient air pollution contributes significantly in reducing life expectancy and increasing mortality"

10	Hill, Jorgenson, Ore, Balistreri and Clark (2019)	2000 to 2010	"air quality and life expectancy in the United States: the moderating effect of income inequality"	United States	"two-way fixed-effects panel regression techniques"	life expectancy	particulate air pollution exposure	"the association between state $PM_{2.5}$ levels and average life expectancy intensifies in states with higher levels of income inequality. More specifically, $PM_{2.5}$ levels are more detrimental to population life expectancy in states where a higher percentage of income is concentrated in the top 10% of the state income distribution".
11	Cheng, Li, Li, and Tang (2019)	1970 to 2010	"response of global air pollutant emissions to climate change and its potential effects on human life expectancy loss in China"	China	"the air pollutant emission simulation model (GAINS) with 3 versions and CMIP5".	life expectancy	particulate air pollution exposure	"the total global emission of major air pollutants increased 1.32 times during 1970–2010".

12	Agbanike, Nwani, Uwazie, Uma, Anochiwa, Igberi and Ogbonnaya (2019)	1971 to 2014	“the linkage between oil, environmenta l pollution and life expectancy in Nigeria”	Nigeria	"autoregressive distributed lag (ARDL) bounds testing approach"	life expectancy	CO2 emissions	“while oil export provides the revenue required to improve life expectancy in the country, it also generates economic conditions that accelerate environmental pollution (carbon dioxide) emissions which further leads to a significant deterioration in life expectancy in Nigeria in the long run”.
13	Balakrishn an, Dey, Gupta, Dhaliwal, Brauer, Cohen and Dandona (2019)	2017	“the impact of air pollution on deaths, disease burden, and life expectancy across the states of India: the Global Burden of Disease Study	India	Descriptive statistics	life expectancy	“ambient particulate matter pollution and household air pollution”	“12·5% of the total deaths were attributable to air pollution, including 0·67 million (0·55–0·79) from ambient particulate matter pollution and 0·48 million (0·39–0·58) from household air pollution”.

			2017”.					
14	Igbinedion (2019)	1990 to 2016	"environmental emissions and life expectancy: further evidence from Nigeria"	Nigeria	“Johansen co-integration and error correction modelling”.	life expectancy	"per capita carbon dioxide as the independent variable representing environmental emissions"	“environmental emission exert significant effect on life expectancy at birth in Nigeria”.
15	Majeed and Ozturk (2020)	1990 to 2016	“environmental degradation and population health outcomes: a global panel data analysis”	180 nations	“fixed-effects approach based on Hausman test, two-stage least squares (2SLS) and system-generalized method of moments (SGMM)”	“life expectancy and infant mortality	CO_2 emissions	“environmental degradation negatively influences population health outcomes”

16	Shah, Wang, Ullah, Akbar, Khan and Bah (2020)	1999Q 1 to 2017Q 4	“does environment quality and public spending on environment fluence life expectancy in China?”	China	“nonlinear autoregressive distributed lag model (ARDL) approach”	life expectancy	“ambient particulate matter pollution and public spending on environment"	increasing spending on environment and environmental quality promote life expectancy
17	Poças, Soukiazis and Antunes (2020)	1990 to 2016	“factors explaining life expectancy at age 65 from the angle of a panel data approach	20 European Union Countries	panel Least Squares method	life expectancy	“population structure, health resources, lifestyles and environment "	“risky lifestyles and air pollution have a significant negative impact on health”
18	Rahman, Rana and Khanam (2020)	2000 to 2017	“determinant s of life expectancy in most polluted countries".	31 world’s most polluted countries	The panel corrected standard errors (PCSE) and feasible general least square (FGLS)	life expectancy	“health expenditure, clean water and improved sanitation"	presence of negative effect of environmental degradation on life expectancy

19	Matthew, Owolabi, Osabohien, Urhie, Ogunbiyi, Olawande and Daramola (2020)	2000 to 2018	“effect of carbon emissions on agricultural output and life expectancy in West Africa”.	West Africa	“two-stage least squares econometric technique”.	agricultural output and life expectancy	CO2 emissions	“carbon emissions harmfully impact on agricultural output, but serves as a boost to life expectancy in the context of West Africa”.
20	Khanzadi, Jaliliyan, Moradi and Heidariyan (2020)	2003 to 2014	“effects of environment quality improvement on life expectancy".	Iran	“Generalized Method of Moments”.	life expectancy	CO2 emissions	“environmental pollution exhibits a significant negative impact on life expectancy, suggesting that increasing CO2 emissions reduced life expectancy in Iran provinces”.
21	Osabohien, Aderemi, Akindele and Okoh (2020)	1980 to 2017	“carbon emissions and life expectancy in Nigeria”.	Nigeria	“The Autoregressive Distributed Lag (ARDL) model	life expectancy	CO2 emissions	“carbon emissions are significant and negatively affect life expectancy”.

22	Jorgenson, Thombs, Clark, Givens, Hill, Huang and Fitzgerald (2021)	not stated	“estimating cross-national longitudinal models to test whether the negative relationship between life expectancy and PM2.5 concentration is larger in nations with higher levels of income inequality”.	not specific	cross-national longitudinal models	life expectancy	were “PM2.5 concentration, income inequality, and the two-way interaction between them”	“negative relationship between life expectancy and PM2.5 concentration and this was larger in nations with higher levels of income inequality”.

23	Murthy, Shaari, Mariadas and Abidin (2021)	1992 to 2017	"relationships between co2 emissions, economic growth and life expectancy in the D-8 countries (Malaysia, Indonesia, Bangladesh, Nigeria, Egypt, Iran, Pakistan, and Turkey) from 1992 to 2017".	D-8 countries	panel ARDL method	life expectancy	CO2 emissions, population growth, health expenditure, economic growth	"economic growth, population growth and health expenditure significantly and positively affect life expectancy, while CO2 emissions exerted a significant negative effect on life expectancy"
24	Rjoub, Odugbesan, Adebayo and Wong (2021)	1960 to 2018	"carbon emissions, economic growth, and life expectancy in Turkey"	Turkey	"Bayer–Hanck cointegration test, wavelet coherence, Fourier Toda–Yamamoto, and Breitung–Candelon frequency-domain spectral causality tests".	life expectancy	"carbon emissions and economic growth"	"a positive co-movement between life expectancy and CO2"

3.5 Analysis of Empirical Gap

Essentially, the outcomes from the previous empirical studies were insightful. It is interesting that, in recent times, a number of earlier studies such as Sarkodie, Strezov, Jiang and Evans (2019), Hill, Jorgenson, Ore, Balistreri and Clark (2019), Cheng, Li, Li, and Tang (2019), Balakrishnan, Dey, Gupta, Dhaliwal, Brauer, Cohen and Dandona (2019), Majeed and Ozturk (2020), Shah, Wang, Ullah, Akbar, Khan and Bah (2020), Poças, Soukiazis and Antunes (2020), Rahman, Rana and Khanam (2020), Matthew, Owolabi, Osabohien, Urhie, Ogunbiyi, Olawande and Daramola (2020), Khanzadi, Jaliliyan, Moradi and Heidariyan (2020), Jorgenson, Thombs, Clark, Givens, Hill, Huang and Fitzgerald (2021), and Rjoub, Odugbesan, Adebayo and Wong (2021) have been conducted with particular interest in other countries, with a view to evaluating the impact of environmental emissions on life expectancy in recent years.

The reverse is the case in the context of Nigeria, notwithstanding the increasing economic activities particularly those in the oil and gas, transportation and agricultural sectors in recent years. The oil pollution in the Niger-Delta region has remained worrisome as the host communities whose lives and sources of livelihood are in danger of obliteration. The implication is that, most of the studies conducted in the context of Nigeria have not adequately addressed the issues of environmental emissions as they relate to life expectancy in the context of Nigeria in recent years, which is a major drive of this study.

Another notable gap identified in the reviewed literature is the choice of proxies for environmental emissions. For instance, it was revealed that the bulk of the earlier studies discussed above focus only on Carbon dioxide (CO_2) emission with no due regard for other mission sources such as methane emissions and Nitrous Oxide emissions which have been proven to be other sources of threats to the ecosystem (EPA, 2021). This present study thus aims to bridge the gap by introducing both methane emissions and Nitrous Oxide emissions as significant improvement on previous models of life expectancy relating to environmental emissions.

In the context of Nigeria, it can be argued that most of the earlier studies are lagging behind time notwithstanding the increasing economic activities in the country in recent years. For instance, it was established that among the earlier studies that attempted to investigate the link between life expectancy and environmental emissions in Nigeria, the studies of Amuka, Asogwa, Ugwuanyi, Omeje and Onyechi (2018), Nkalu and Edeme (2019), Agbanike, Nwani, Uwazie, Uma, Anochiwa, Igberi and Ogbonnaya (2019), Igbinedion (2019), Osabohien, Aderemi, Akindele and Okoh (2020), Murthy, Shaari, Mariadas and Abidin (2021) made similar contribution. However, the known most recent year covered by these studies in their empirical analysis was as far back as 2017, thus creating a significant gap in the literature. Interestingly, this present study will be extended to a coverage period of fifty (50) years (1970 to 2019) based on data availability from relevant sources.

This is to capture the effects of the significant economic activities that have occurred in Nigeria with the tendency to induce rising cases of environmental emissions in the country.In obedience to the law of statistical regularity as well as the law of large sample, the large number of observations will also enhance the degree of freedom in the empirical assessments, thereby boosting the quality and accuracy of estimates generated for the period under investigation.

3.6 Conceptual Framework

This section presents the conceptual framework (model) that forms the basis of the structural modelling in subsequent sections. The conceptual framework is a diagrammatic representation of the various channels through which life expectancy can be influenced.

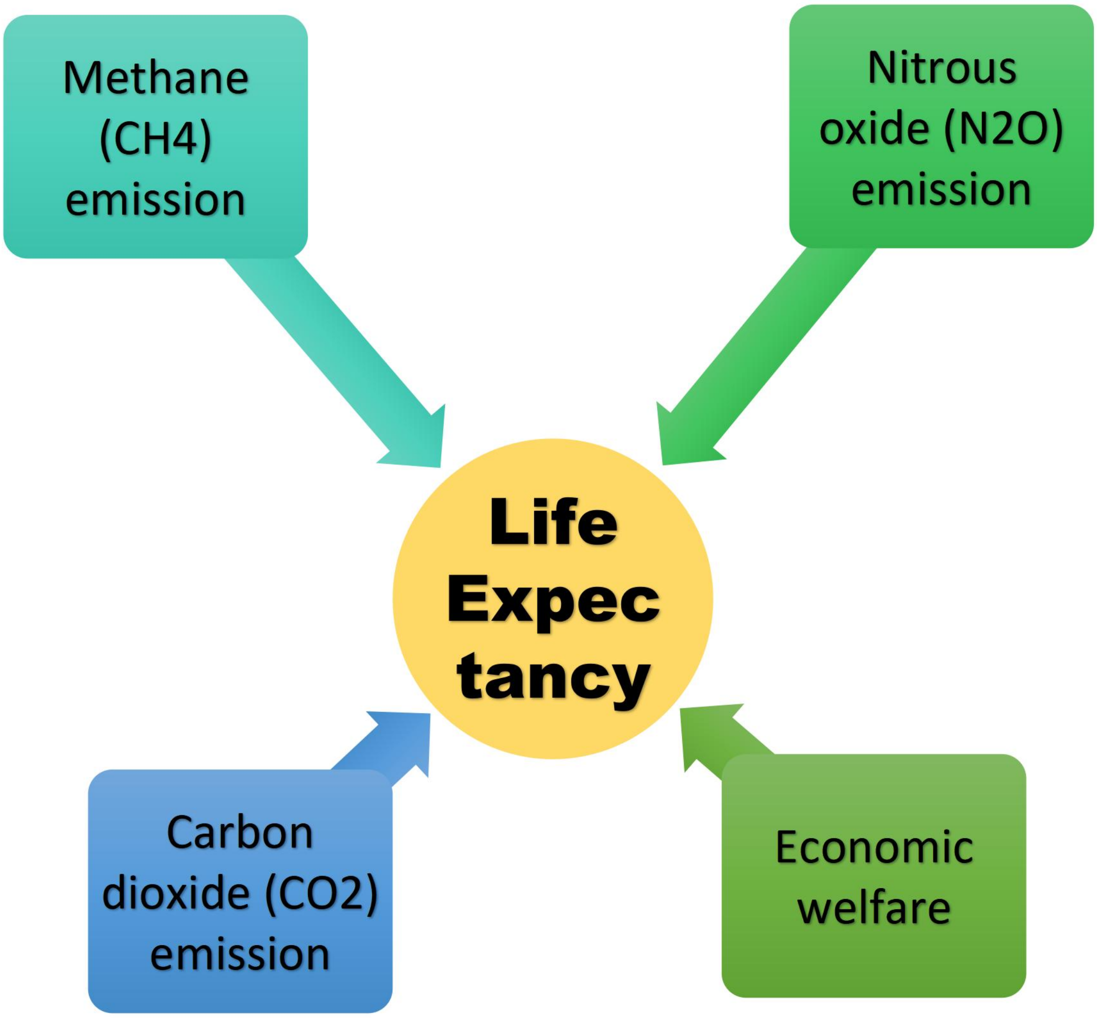

Figure 9: The planned Conceptual Framework (Model) of the study

Source: Author (2021)

CHAPTER FOUR

THEORETICAL FRAMEWORK, MODEL SPECIFICATION AND METHODOLOGY

4.1 Introduction

This chapter presents the description of research technique adopted in establishing the effects of environmental emissions on life expectancy in Nigeria. Specifically, the chapter entails the discussion of the theoretical framework, model specification, estimation technique, including the preliminary tests, main analysis, post-estimation tests, method of data collection as well as apriori expectations.

4.2 Theoretical Framework

The study adapts the Human-Environment interaction model developed in the work of Hammond in 1995. This model demonstrates the mechanisms through which human constantly interrelate with the natural environment and further reveals the extent to which human engage in environmentally unhealthy activities which in turn result in exert reverse causality on man.

Specifically, the theory posits that, individuals obtain all forms of "minerals, energy, food, fibers, and other natural resources that are daily utilized in the economy" which can degrade the biological structures like land on which both agricultural activities and manufacturing processes are carried out on regular basis. Also, "natural resources are transformed by industrial activity into products (such as pesticides) and energy services that create pollution and wastes that flow back into the environment". Thus, the release of harmful substances into the ecosystem has the tendency to reduce human lifespan due to the deteriorating effect of these harmful elements in the atmosphere.

The basic assumption of this model in relation to the subject of this research, is that several elements such as Poisoned air and water as well as contaminated food substances exert harmful effects on human health and well-being directly. The long run impact of these elements is the reduction of the expected lifespan of humans, thus, a decline in life expectancy. Thus, in a nutshell, it is assumed that both Carbon dioxide (CO_2) emission (Majeed and Ozturk, 2020; Matthew, *et al,* 2020; Khanzadi, *et al.,* 2020; Osabohien, *et al.,* 2020; Murthy, *et al.,* 2021; Rjoub, *et al.,* 2021), Methane (CH_4) emission, and Nitrous oxide (N_2O) emission influence life expectancy. However, the modeling framework of this study will be expanded with the incorporation of per capita income as a proxy for economic welfare earlier adopted in the studies of Sarkodie, Strezov, Jiang and Evans (2019) as well as Igbinedion (2019).

4.3 Model Specification

From the conceptual framework (model) as well as the theoretical framework presented above, the augmented model to be estimated for this study is specified below;

LEXP = f(CO2, CH4, N2O, PCI) - 1

Stating explicitly, the above model can be parameterized in the following structural form;

$LEXP_t = \beta_0 + \beta_1 LEXP_t + \beta_2 CO2_t + \beta_3 CH4_t + \beta_4 N20 + \beta_5 PCI_t + \mu_t$ - - - - - - - - 2

Where;

LEXP = life expectancy

CO2 = Carbon dioxide emission

CH4 = Methane emission

N2O = Nitrous oxide emission

PCI = per capita income (a measure of economic welfare)

β_0 is the intercept,

$\beta_1\ to\ \beta_5$ = Parameters

μ = Error Term

t = time period

Essentially, following the technique advanced by Pesaran and Shin (1995) in modeling the long-run and short-run dynamic linkage amongst variables, the autoregressive distributed lag (ARDL) model is presented as follows;

$$\Delta y_t = u + \rho_y y_{t-1} + \rho_x x_{t-1} + \sum_{i=0}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{i-1}^{q-1} \beta_i \Delta x_{t-i} + \xi_t \ldots\ldots(3)$$

Where y is the explained variable and x is the list of selected predictors, ρ, α and β are coefficients, and μ signifies the constant parameter. The above specification can further be decomposed and represented as follows;

$$\Delta y_t = \rho y_{t-1} + \theta^{+} x_{t-1}{}^{+} + \theta^{-} x_{t-1}{}^{-} + \eta z_{t-1} + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{p} (\varphi_i{}^{+} \Delta x_{t-i}{}^{+} + \varphi_i{}^{-} \Delta x_{t-i}{}^{-}) + \sum_{i=1}^{q-1} \gamma_i \Delta z_{t-i} + \xi_t \ldots (4)$$

Where y is the explained variable which represents life expectancy, x is the theorized asymmetric series (Carbon dioxide (CO2) emission, Methane (CH4) emission, and Nitrous oxide (N2O) emission), z denotes other regressors that serve as control variables (per capita income). In order to capture both the short run and long run determinants, variables in equation (2) are substituted into (4) to yield the following;

$$\Delta LEXP_t = \beta_0 + \sum_{i=0}^{k} A_i \, \Delta LEXP_{t-i} + \sum_{i=0}^{l} B_i \, \Delta CO2_{t-i} + \sum_{i=0}^{m} \mathrm{C}_i \, \Delta CH4_{t-i} + \sum_{i=0}^{n} D_i \, \Delta \mathrm{N2O}_{t-i} + \sum_{i=0}^{n} E_i \, \Delta \mathrm{PCI}_{t-i} + \beta_1 LEXP_{t-i} + \beta_2 CO2_t + \beta_3 CH4_t + \beta_4 N20 + \beta_5 PCI_t + \mu_t \ldots\ldots 5$$

A, B, C, D and E are the short run parameters in the model,

β_1 *to* β_5 = long run Parameters

Δ =first order integration.

Hence, the long-run relationship ($\beta^{+} = \beta^{-}$) or the symmetric short-run parameters can be tested with the aid of the Wald Statistic in line with the X_k^2 distribution generated from the Bounds tests (Pesaran and Shin, 1995).

4.4 Estimation Techniques

The procedure of data analysis for this study is divided into three phases; the first phase entails the pre-Estimation; the second phase involves the estimation and the concluding stage covers the post-estimation analysis. The preliminary analysis entails the descriptive characteristics of the variables to be utilized in this study. Such characteristics include mean, standard deviation, skewness and kurtosis.

Facts about the stationarity status of the variables will also be presented in the pre-estimation stage. The main estimations encompass the evaluation of the parameters of the autoregressive distributed lag (ARDL) model. The post estimation analysis is crucial for the determination of the consistency and stability of the estimated parameters for inferential purposes and policy considerations.

4.4.1 Pre-Estimation

Preliminary analysis of the data will be offered in this segment. First, the summary statistics of the selected variables will be reported. These include the average, standard deviation, skewness which can either be positive or negative as well as other statistic to have a thorough summary description of the variables. Also, Formal pre-test of the data will be conducted due to the large number of observations to ensure a robust analysis. The major tests considered under this sub-section are discussed here under;

1. **Unit Root test:** This test will be conducted in order to determine the stationarity of each variable. The unit root test is carried out on each of the variable to be utilised in this study. Explicitly, the study will employ the Augmented Dickey-Fuller (ADF) test and Phillip-Perron (PP) test for robustness purpose.

2. **Bounds test:** Having established the stationarity position of the variables, the study will then we advance to test for possible long run relationship among variables in the econometric models. The selection of the appropriate technique for testing for possible co-integration will be greatly determined by the result obtained from the unit root tests conducted as specified above.

4.4.2 Estimation

The autoregressive distributed lag (ARDL) and bounds testing approach will be utilized in analyzing the data to be employed in this study. This is to enable us evaluate the short run and long run impacts of the respective regressors on life expectancy.

4.4.3 Post Estimation

Having estimated the short run and long run coefficients of the variables, the study will further carry out autocorrelation, heteroskedasticity, and omitted variables bias tests. This is to strengthen the efficiency, consistency and reliability of the estimates obtained in the estimation process.

4.5 The Data

This study aims to evaluate the effects of environmental emissions on life expectancy with particular emphasis on Nigeria. Thus, empirical discussions will be established on three key independent variables which include Carbon dioxide (CO2) emission, Methane (CH4) emission as well as Nitrous oxide (N2O) emission. Similar discussion will also be drawn from the controlling/intervening effect of economic welfare in the course of empirical analyses in this study. In addition, the study will employ annual data set for a period of fifty (50) years spanning 1970 to 2019. This is to further account for more degree of freedom, while absorbing relevant periods of the various environmental policy reforms in the country into the empirical analysis.

Similarly, data on Carbon (iv) dioxide emissions in Nigeria (million tonnes), Methane emissions (million tonnes) in Nigeria and Nitrous Oxide emissions (million tonnes) in Nigeria will be derived from the Global Carbon Project (2020), while data on per capita income will be obtained from World Development Indicators of the World Bank (2020). Similarly, data on Life expectancy at birth (years) will be sourced from the United Nations World Population Prospects (2019).

4.6 Apriori Expectations

Essentially, Carbon (iv) dioxide emissions, Methane emissions and Nitrous Oxide emissions are expected to have statistically significant negative impacts on life expectancy, while per capita income is expected to exert statistically significant positive impact on life expectancy both in the short run and in long run.

CHAPTER FIVE

PRESENTATION, ANALYSIS OF DATA AND DISCUSSION OF FINDINGS

5.1 Introduction

Recall that the focus of this study is to empirically evaluate the effects of environmental emissions on life expectancy in the context of Nigeria. Thus, this chapter presents and discusses the empirical results from the study. The first segment of the chapter covers a detailed discussion of the descriptive statistics of the principal variables in this study which include Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, total, Nitrous Oxide emissions and Real GDP per capita. Other sections of the chapter present the pre-estimation tests, main estimation results from the model as well as post-estimation tests. The last segment of the chapter presents the policy implications of research findings.

5.2 Descriptive Statistics

The summary statistics of all the series employed in this study include the mean, median, minimum and maximum values, standard deviation, the skewness and kurtosis, Jarque-Bera values and their equivalent probability values reported in Table 4.1. Essentially, the mean of each of the variable implies the average of the respective trend, while the standard deviation indicates the explosive nature of the specific series under investigation. Furthermore, the skewness and kurtosis indicators indicate the asymmetry and peakedness of the distribution whereas the Jarque-Bera statistic shows whether the variable is normally distributed or not.

From table 4.1, Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita averaged 88.60 million tonnes, 73.75 million tonnes, 47.01years, 23.57 million tonnes and ₦27,380 respectively, while their standard deviations were reported as follows; Methane emissions (31.55 million tonnes), Carbon (iv) dioxide emissions (32.87 million tonnes), Life expectancy at birth (3.45 years), Nitrous Oxide emissions (8.50 million tonnes) and Real GDP per capita (₦6,110), during the estimation period.

Specifically, the result shows that from 1970 to 2019, Methane emissions accounted for a total of 4,429.77 million tonnes (highest volume of environmental emissions), while Carbon (iv) dioxide emissions represented a total of 3,687.33 million tonnes. Also, Nitrous Oxide emissions accounted for a total of 1,178.67 million tonnes in the same period of assessment.

Also, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita were positively skewed (right-skewed), while Methane emissions was negatively skewed (left-skewed) in the period of assessment. In the same vein, Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita were platykurtic (with small kurtosis values, less than 3) in their distributions, suggestive of the presence of small outliers in the distributions.

The Jarque-Bera statistic reveals that, all the series utilized in the study (Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita) were normally distributed during the period of assessment. This is validated from the associated Jarque-Bera probability values which were all greater than 0.05 (5%) critical level. Table 4.1 reports the descriptive statistics of the variables used in the study below.

Table 5.1: Descriptive statistics of the variables used in the study

Stat	Methane emissions (million tonnes) in Nigeria	Carbon (iv) dioxide emissions in Nigeria (million tonnes)	Life expectancy at birth, total (years)	Nitrous Oxide emissions (million tonnes) in Nigeria	Real GDP per capita (N'000)
Mean	88.60	73.75	47.01	23.57	27.38
Median	98.98	68.72	45.99	22.67	27.42
Maximum	142.07	140.03	54.49	38.82	38.53
Minimum	35.20	21.52	40.79	11.47	19.90
Std. Dev.	31.55	32.87	3.45	8.50	6.11
Skewness	-0.14	0.45	0.53	0.11	0.30
Kurtosis	1.53	1.99	2.67	1.67	1.72
Jarque-Bera	4.66	3.80	2.58	3.78	4.12
Probability	0.10	0.15	0.28	0.15	0.13
Sum	4429.77	3687.33	2350.64	1178.67	1369.10
Observations	50	50	50	50	50

Source: Author's Computation (2021) *Using E-views 12*

5.3 Testing for Stationarity

In line with the earlier suggestion of Granger and Newbold (1974), most time series variables always trend in a non-stationary mode at their level distribution. Similarly, when such non-stationary variables are used to estimate the behaviour of another variable (dependent variable) in a regression model, the parameter estimates that are produced thereof will be spurious in nature, suggesting that they are not good of policy analysis and endorsements. It is in deep recognition of this fact that this study carried out stationarity tests by espousing both the Augmented Dickey-Fuller (ADF) and Philip-Perron (PP) unit root tests (Dickey, & Fuller, 1981; Phillips & Perron 1988) and the results are reported in Table 4.2 through Table 4.3.

Essentially, the purpose of the stationarity test was to evaluate the stationarity properties of Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita, as well as to establish whether they are stationary at levels or at differences. The results from both ADF and PP unit root tests reported in Table 4.3 jointly reject the null hypothesis of unit root for all variables at their first difference given that the absolute values of both ADF and PP tests were greater than the critical values.

Therefore, the null hypothesis which states that the series is not stationary can be dismissed, since the results in Table 4.3 show that all the variables under consideration are stationary at 1% significant level. Precisely, Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita exhibit a common unit root process (same order/first difference integration) in the period of assessment.

This in turn suggests the relevance of using the ARDL Bounds estimation technique since the theoretical establishment is premised on stationarity assumption (Pesaran & Shin, 1995). From the stationarity test results, all the series were found to be stationary, although not at levels, but at first difference

I(1). Clearly, all the variables fluctuate round a long-run mean that is approximately zero. The stationarity tests results are reported in Table 4.2 through Table 4.3. below.

Table 5.2: Stationarity Tests at Levels- Augmented Dickey-Fuller and Phillips-Perron Tests

Variables	Test statistic	Critical values			Remarks
		1%	**5%**	**10%**	
		Panel A. Augmented Dickey Fuller Tests Results at Levels			
lnCH4	-1.75	-3.57	-2.92	-2.60	Non-stationary
lnCO2	-2.13	-3.57	-2.92	-2.60	Non-stationary
lnlEXP	0.53	-3.57	-2.92	-2.60	Non-stationary
lnCN2O	-0.99	-3.57	-2.92	-2.60	Non-stationary
lnPCI	-0.81	-3.57	-2.92	-2.60	Non-stationary
		Panel B. Phillips-Perron Tests Results at Levels			
lnCH4	-1.76	-3.57	-2.92	-2.60	Non-stationary
lnCO2	-2.18	-3.57	-2.92	-2.60	Non-stationary
lnlEXP	-0.15	-3.57	-2.92	-2.60	Non-stationary
lnCN2O	-0.87	-3.57	-2.92	-2.60	Non-stationary
lnPCI	-1.21	-4.16	-3.50	-3.18	Non-stationary

Source: Author's Computation (2021) *Using E-views 12*

Table 5.3: Stationarity Test at First Difference: Augmented Dickey Fuller and Phillips-Perron Approach

Variables	Test statistic	Critical values			Remarks
		1%	**5%**	**10%**	
Panel C. Augmented Dickey Fuller Tests Results at First Difference					
lnCH4	-6.19***	-3.57	-2.92	-2.60	I(1)
lnCO2	-7.31***	-3.57	-2.92	-2.60	I(1)
lnlEXP	-4.54***	-3.58	-2.93	-2.60	I(1)
lnCN2O	-5.40***	-3.58	-2.93	-2.60	I(1)
lnPCI	-5.44***	-4.16	-3.51	-3.18	I(1)
Panel D. Phillips-Perron Tests Results at First Difference					
lnCH4	-6.18***	-3.57	-2.92	-2.60	I(1)
lnCO2	-7.33***	-3.57	-2.92	-2.60	I(1)
lnlEXP	-6.58***	-3.58	-2.93	-2.60	I(1)
lnCN2O	-9.17***	-3.57	-2.92	-2.60	I(1)
lnPCI	-5.51***	-4.16	-3.51	-3.18	I(1)

NB: * denotes Significant at 1%.**
Source: Author's Computation (2021) *Using E-views 12*

5.4 The Autoregressive Distributed Lag (ARDL) and Bounds testing approach

In order to empirically appraise the long-run linkage and short run dynamic interactions among the series employed in this study, the Autoregressive Distributed Lag (ARDL) and Bounds testing approach advanced in the study of Pesaran and Shin (1995) and improved upon in the study of Pesaran, Shin and Smith (2001) was utilized. One interesting fact about the ARDL and Bounds testing approach is that it does not require all the variables under study to be stationary at the same order (integrated of the same order). Thus, the technique will yield efficient results even if some variables are stationary at level and others at first or second difference (Belloumi, 2014).

Similarly, Belloumi (2014) noted that “the ARDL test is relatively more efficient in the case of small and finite sample data sizes”. Another interest fact about the ARDL is that it produces unbiased short run and long-run estimates as well as the error correction term that reconciles the short run divergence with the long run convergence (Harris and Sollis, 2003).

5.4.1 ARDL Bounds tests for cointegration

Essentially, the ARDL Bounds Test is governed by the Null Hypothesis that the variables in the ARDL model have no long-run relationships. The decision rule is that, when the resultant F-statistic is below the lower bound (I0 Bound), we fail to reject the Null Hypothesis, implying that there is no long-run relationship among the variables. On the other hand, when the resultant F-statistic is above the upper bound (I1 Bound), the Null Hypothesis is rejected, implying that long-run relationships exist among the variables in the model.

However, when the resulting F-statistic is between the I0 and I1 Bounds, the results remain inconclusive. Interestingly, from the ARDL Bounds Test Results presented in Table 4.4, the F-statistic (70.50) is greater than the I1 Bound (5.06) at 1% critical level. The implication is that long-run relationships exist among the variables in the ARDL model. This further corroborates the choice of ARDL method adopted in this present study. Table 4.4 reports the ARDL Bounds Test Results below.

Table 5.4: ARDL Bounds Test Result

Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	70.50	4

Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.50%	3.25	4.49
1%	3.74	5.06

Source: Author's Computation (2021) *Using E-views 12*

5.4.2 Empirical Results and Discussion of Findings

As noted earlier, the main task of establishing the effects of environmental emissions on life expectancy in Nigeria was carried out using the ARDL and Bounds testing method and the results obtained from both the short run and long run estimations are presented in Table 4.5. Having confirmed that the variables are stationary and co-integrated, the error correction representation of the selected model (with 1, 2, 2, 2, 2 lag Selected automatically selected by the system as the optimal lag length) and long run estimates are presented and discussed.

Specifically, the error correction model captures the short-run deviations that might have resulted in estimating the long-run co-integrating equations. Also, the error correction representation captures an error correction variable (ECM) which is used to measure the speed of adjustment of life expectancy in Nigeria to its long-run equilibrium. In addition, the system automatically selected and reported the results using the maximum lag length of 2 which is the optimal Lang length entering the ARDL modelling framework of the study.

From the estimation result presented in Table 4.5, the coefficient of ECM (-0.117) was negative and statistically significant at 1% critical level. The implication is that about 11.7% of the short run dynamics in life expectancy in Nigeria was corrected in the estimation process. Interestingly, Kalim and Hassan (2014) noted that a "significant error correction coefficient is another avenue to validate the existence of a long run relationship among the variables in a regression model".

From the ARDL results presented in Table 4.5, it was established that the coefficient of Carbon (iv) dioxide emissions and its associated one-period lag were both negative in the short run estimated results. However, it was positive in the long run. similarly, the result revealed that Carbon (iv) dioxide emissions and its associated one-period lag were statistically significant at 1% critical level in the long run and short run estimation results respectively.

The implication of negative the coefficient of Carbon (iv) dioxide emissions and its associated one-period lag is that the more these emission gases are released into the environment, there will be a rise in the human health negative effects. It therefore follows that as these emission gases are released into the atmosphere, there is a tendency that the human life span will be shortened, thus, reducing the total life expectancy in the country. The result however implies that an increase in Carbon (iv) dioxide emissions and its associated one-period lag by 1% respectively, will lead to about 0.001% and 0.003% decline in Life expectancy at birth in Nigeria in the short run.

Nevertheless, the result shows that, a similar increase in Carbon (iv) dioxide emissions by 1% will cause a 0.03% rise in Life expectancy at birth in Nigeria in the long run. though, this is in dissonance with apriori expectation. In all, the result suggests that the negative effects of Carbon (iv) dioxide emissions on human health are significantly felt after one year as evidenced by the significant negative coefficient of one-period lagged Carbon (iv) dioxide emissions.

Generally, this finding on the negative effects of Carbon (iv) dioxide emissions on Life expectancy validates the result of previous studies such as Nkalu and Edeme (2019), Agbanike, et al. (2019), Osabohien, et al. (2020), Majeed and Ozturk (2020), Khanzadi, et al. (2020), Murthy, et al. (2021) who established that Carbon (iv) dioxide emissions exerted a significant negative impact on Life expectancy at birth across various geographical areas. Similarly, the finding on the long run positive effects of Amuka, et al. (2018), Matthew, et al. (2020), and Rjoub, et al. (2021) who revealed inter alia that carbon dioxide emission exhibits a positive effect on life expectancy across various states, or countries.

Similarly, the empirical results established that the coefficient of Methane emissions was negative and statistically significant at 1% critical level in the short run estimation results, while its associated one-period lag was positive and statistically significant at 10% critical level in the short run estimation result in the period of assessment. Similarly, the result indicated that Methane emissions was negative and statistically significant at 1% critical level in the long run estimation results.

The general implication of the negative short run and long run coefficient of Methane emissions is that, as these gases are released into the atmosphere, they have the tendency to deteriorate the general health and wellbeing of individuals who are exposed to them. Since it is well established that these emission gases can live in the atmosphere of a long period of time, with the potential to cause harm through the release of airborne (the United States Environmental

Protection Agency, 2021), when these gases stay in the atmosphere for long, they become globally mixed in the air and their absorptions become major emissions sources globally. Thus, the progressive deterioration in human health occasioned by the constant release of these environmentally hostile gases will in turn lead to a decline in Life expectancy at birth through adverse health outcomes.

The result generally depict that the frequent and unregulated release of Methane emissions especially during industrial and agricultural activities, burning of wood, raising of lives stock, bush burning, decomposition of organic waste, combustion of solid waste and burning of fossil fuel (natural gas, oil and coal) will continue to exert a depressive effect on climate (Melillo, Richmond & Yohe, 2014) leading to global warming and a negative impact will result in the health and general wellbeing of individuals in the society. This will exert negative implication for the life expectancy in the country.

The result however implies that an increase in Methane emissions by 1% respectively, will lead to about 0.004% and 0.07% decline in Life expectancy at birth in Nigeria in the short run and long run respectively, while a similar increase in one-period lagged Methane emissions by 1% will cause a 0.005% rise in Life expectancy at birth in Nigeria in the short run. Though, this is finding invalidates apriori expectation.

Furthermore, the coefficient of Nitrous Oxide emissions was positive both in the short run and long run estimation results. Though, this is finding contradicts apriori expectation, the coefficient of its associated one-period lagged series became negative and statistically significant at 10% critical level in the short run estimation result in the period of assessment. This is in line with the expected outcome. The result further established that while the coefficient of Nitrous Oxide emissions was statistically significant at 10% critical level in the short run, it became statistically significant at 1% critical level in the long run.

The negative relationship between one-period lagged Nitrous Oxide emissions and Life expectancy at birth in Nigeria depicts that, just like Carbon (iv) dioxide emissions, the recurrent and unregulated release of these emissions gases into the ecosystem in the course of "agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater" will continue to exert a depressive effect on climate (Zhang, *et al*, 2021; Gong, Juang & Wasowski, 2021) leading to global warming. Also, as these gases mixed with the atmospheric air, there will be a negative impact on the health and general wellbeing of individuals in the society in the course on respiration. This will exert negative implication for the life expectancy in the country as well.

Specifically, as nitrous oxide emissions trap some of the Earth's outward energy, they will recollect heat in the atmosphere. When this heat is constantly trapped from the atmosphere, there will be changes in the radiative balance of the Earth. This yields a significant imbalance between the amount of energy generated from the sun as well as the amount that is discharged from Earth.

The resultant effect is a rise in global warming which in turn exert a negative impact on the health of humans, thus reducing human life expectancy.

Interestingly, the result suggests that the negative effects of Nitrous Oxide emissions on human health are significantly felt after one year as evidenced by the significant negative coefficient of one-period lagged Nitrous Oxide emissions. This is also similar to the result obtained in the case of one-period lagged Carbon (iv) dioxide emissions.

The result however implies that an increase in Nitrous Oxide emissions by 1% respectively, will lead to about 0.004% and 0.19% increase in Life expectancy at birth in Nigeria in the short run and long run respectively, while a similar increase in one-period lagged Nitrous Oxide emissions by 1% will cause a 0.005% decline in Life expectancy at birth in Nigeria in the short run.

Similarly, the coefficient of real GDP per capita and its associated one-period lag (in line with the apriori expectation) was positive both in the short run and long run estimation results in the period of assessment. Though, the coefficient of its associated one-period lagged series became negative and statistically significant at 1% critical level in the short run estimation result in the period of assessment. This is in disagreement with the expected outcome. The result further established that while the coefficient of real GDP per capita was statistically insignificant in the short run, it was found to be statistically significant at 1% critical level in the long run estimation results.

The general implication of the short run and long run positive coefficient of real GDP per capita is that, as the level of economic welfare in the country increases, individuals will have access to means of enhancing their livelihoods and take good care of their selves through healthy diet, good shelter and access to health care services which all have the tendency to boost their general health and wellbeing. When this occurs, the level of mortality will drop, thus, leading to improved human life span in the country.

Interestingly, this finding validates the results of previous study of Sarkodie, *et al.* (2019) who found among others that GDP per capita, contributes significantly in promoting life expectancy and decreasing mortality. The result however implies that an increase in real GDP per capita by 1% will lead to about 0.035% and 0.20% increase in Life expectancy at birth in Nigeria in the short run and long run respectively, while a similar increase in one-period lagged GDP per capita by 1% will cause a 0.016% decline in Life expectancy at birth in Nigeria in the short run.

The coefficient of determination (R^2) showed that, about 0.9997 or 99.97% of the systematic changes in the Life expectancy at birth in Nigeria is accounted for by the joint influence of Methane emissions, Carbon (iv) dioxide emissions, Nitrous Oxide emissions and real GDP per capita, while the remaining 0.03 percent is due to other factors captured by the stochastic disturbance term in equation (5) earlier specified in this study. This further confirms that the model is well-fitted. Finally, the F-statistic (7999.33) and the associated Probability value (0.00) revealed that the model is generally significant at 1% test level.

Thus, the estimation results obtained in this study are presented in Table 4.5 below.

Table 5.5: Error Correction Representation of the Selected Model and Long Run Estimation Results

Dependent Variable: LNLEXP
Selected Model: ARDL(1, 2, 2, 2, 2)
Method: ARDL

Error Correction Representation of the Selected Model				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.34	0.04	8.27	0.00***
D(LNCO2)	-0.001	0.00	-0.55	0.59
D(LNCO2(-1))	-0.003	0.00	-3.02	0.00***
D(LNCH4)	-0.004	0.00	-3.60	0.00***
D(LNCH4(-1))	0.005	0.00	1.96	0.06*
D(LNN2O)	0.004	0.00	1.74	0.09*
D(LNN2O(-1))	-0.005	0.00	-1.71	0.10*
D(LNPCI)	0.003	0.00	1.02	0.31
D(LNPCI(-1))	-0.016	0.01	-3.25	0.00***
ECM(-1)	-0.117	0.01	-9.00	0.00***
Long Run Estimation Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.87	0.04	70.57	0.00***
LNCO2	0.03	0.01	3.47	0.00***
LNCH4	-0.07	0.01	-6.48	0.00***
LNN2O	0.19	0.01	13.10	0.00***
LNPCI	0.20	0.02	10.10	0.00***
R-squared	0.9997	Akaike info criterion		-9.99
Adjusted R-squared	0.9995	Schwarz criterion		-9.45
F-statistic	7999.33	Hannan-Quinn criter.		-9.79
Prob(F-statistic)	0.00	Durbin-Watson stat		1.65

NB: *Significant at 10%, **Significant at 5%, and ***Significant at 1%.

Source: Author's Computation (2021) ***Using E-views 12***

5.5 Testing for Autocorrelation/Serial Correlation and Heteroscedasticity

Autocorrelation or Serial Correlation implies that, the residuals (or their lagged values) in a Regression model are correlated, while heteroscedasticity refers to a situation whereby the variances of the residuals and their lagged values in an econometric equation are unequal. Both autocorrelation or serial correlation and heteroscedasticity exhibit serious threats in the field of econometrics, as they greatly affect the parameters in a Regression model and further render the usual F-statistic unreliable (Baltagi, 2021; Aftab, Suhail, Layouni, Khan, Haider & Durrani, 2021; Joshi, Dalei & Mehta, 2021; Ling, Tsay & Yang, 2021).

The Breusch-Pagan-Godfrey test was utilised for the determination of the presence (or otherwise) of serial correlation, while the Harvey test was used to test for heteroskedasticity in the estimated model. Interestingly, given that the resulting probability values of the various test results are greater than 0.05 or 5%, both results revealed that, the ARDL model did not suffer from autocorrelation or heteroscedasticity. The tests results are simultaneously reported in Table 4.6 below.

Table 5.6: Autocorrelation/ Serial Correlation and Heteroscedasticity test results

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.96	Prob. F(2,32)	0.39
Obs*R-squared	2.71	Prob. Chi-Square(2)	0.26
Heteroskedasticity Test: Harvey			
F-statistic	1.33	Prob. F(13,34)	0.24
Obs*R-squared	16.20	Prob. Chi-Square(13)	0.24
Scaled explained SS	24.50	Prob. Chi-Square(13)	0.03

Source: Author's Computation (2021) ***Using E-views 12***

5.6 Testing for Omitted Variables

This study further evaluated likely bias occasioning from variable omission in the ARDL model with the aid of the Ramsey RESET procedure under the Null Hypothesis that there is no omitted variables bias in the specifies ARDL model. Basically, this test was essential with deep acknowledgement that when regression model fails to account for some significant variables there will be a bias in the parameters of the variables included in the model.

Precisely, when variables are mistakenly omitted from a regression model, the actual behaviour of the dependent variable may be inaccurately ascribed to the variables captured in the model. Thus, the omission can lead to overstated errors in the coefficient of each explanatory variable and can alter the accurateness of the estimated coefficients in the regression result (Hai, Nga & Hoa, 2021; Chowdhury, Nijhum & Uddin, 2021).

The test results reported in Table 4.7 support the null hypothesis, since the respective probability values (0.73) were greater than the 5% critical values.

Thus, there was no case of model misspecification or omitted variables bias in this study. Table 4.7 reports the results of the omitted variables bias tests using the Ramsey RESET method.

Table 5.7: Omitted Variables Bias tests-Ramsey RESET Approach

Null Hypothesis: No Omitted Variables Bias

Specification: LNLEXP LNLEXP(-1) LNCO2 LNCO2(-1) LNCO2(-2) LNCH4 LNCH4(-1) LNCH4(-2) LNN2O LNN2O(-1) LNN2O(-2) LNPCI LNPCI(-1) LNPCI(-2) C

Omitted Variables: Squares of fitted values			
	Value	df	Probability
t-statistic	0.35	33	0.73
F-statistic	0.12	(1, 33)	0.73

Source: Author's Computation (2021) ***Using E-views 12***

5.7 Testing for Normality of the ARDL Residuals

As part of robustness checks, the researchers conducted the normality test with the aid of the Jarque-Bera statistic reported in Figure 4.1 below. The test was conducted to further examine if the residuals from the estimated ARDL model follow Normal distribution which is the theoretical underlying assumption of the Classical Linear Regression Model (CLRM) (Uba, Zandam, Mansur & Shukor, 2021; Adamec & Smith, 2021). The results in Figure 4.1 further imply that the residuals regenerated from both models follow normal distribution since the corresponding Jarque-Bera probability value (0.67) is greater than the 5% critical value. Thus, the estimates are robust.

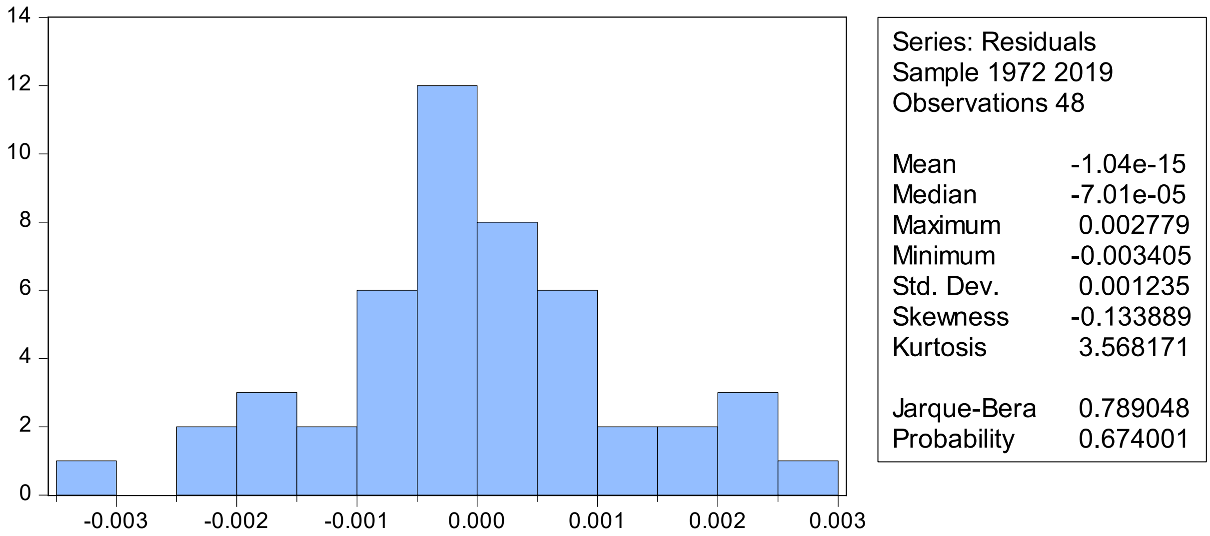

Figure 5.1: ARDL Residual Normality Test result

Source: Author's Computation (2021) ***Using E-views 12***

5.8 Graph of the Residual, Actual and Fitted Observations

The graphs in Figure 4.2 below show that, the actual and the fitted observations from the model clearly coincide with each other. This implies that the forecast and final prediction errors are at minimum point, thus, boosting the accuracy of the parameter estimates in the ARDL model.

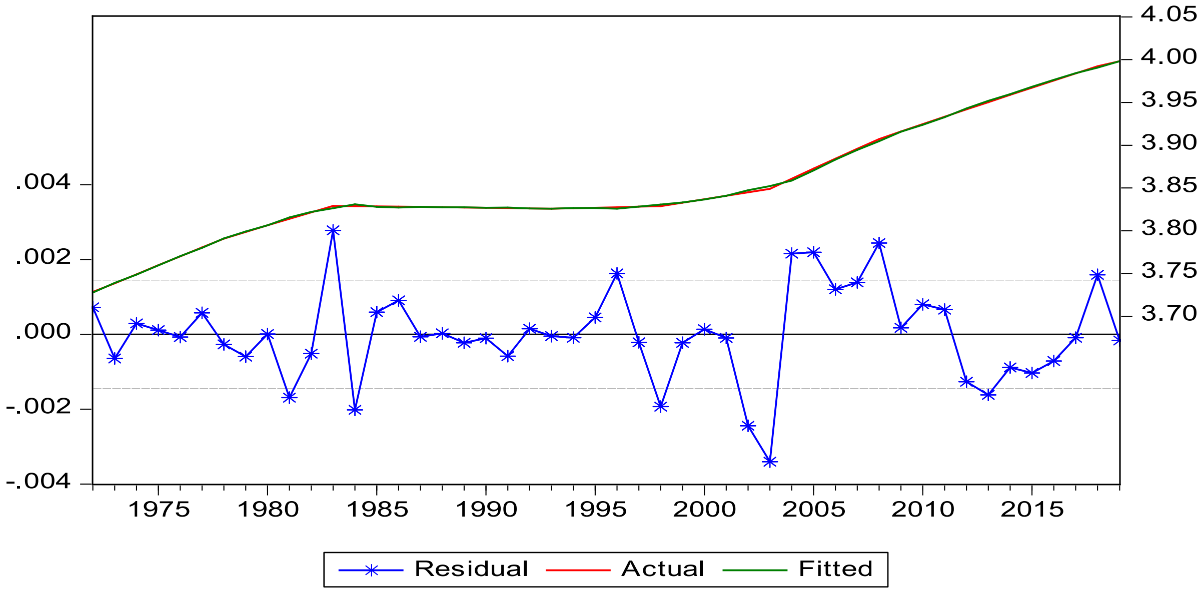

Figure 5.2: Graph of the Residual, Actual and Fitted Observation

Source: Author's Computation (2021) *Using E-views 12*

5.9 Forecasting Life expectancy at birth in Nigeria

In order to further support the above empirical findings, it becomes beneficial to simulate the actual behaviour of Life expectancy at birth in Nigeria with changes in Carbon (iv) dioxide emissions, Methane emissions, Nitrous Oxide emissions and real GDP per capita. This is done by employing forecasting procedures with the E-views application and the result is reported in Figure 4.3 below.

The result shows that, the forecasted Life expectancy at birth in Nigeria (lnLEXPF) remained inside the 2 standard error critical lines, thus confirming the strength and accuracy of the forecast. Also, the forecast result is accurate given the fact that the Theil inequality index of 0.0002 is closer to zero (Zainul, Hanani, Kustiono, Syafrial & Asmara, 2021; Wang & Feng, 2021; Nusantara, Nawatmi, Santosa & Sudiyatno, 2021). This further authenticates the precision of the forecast figures obtained thereof.

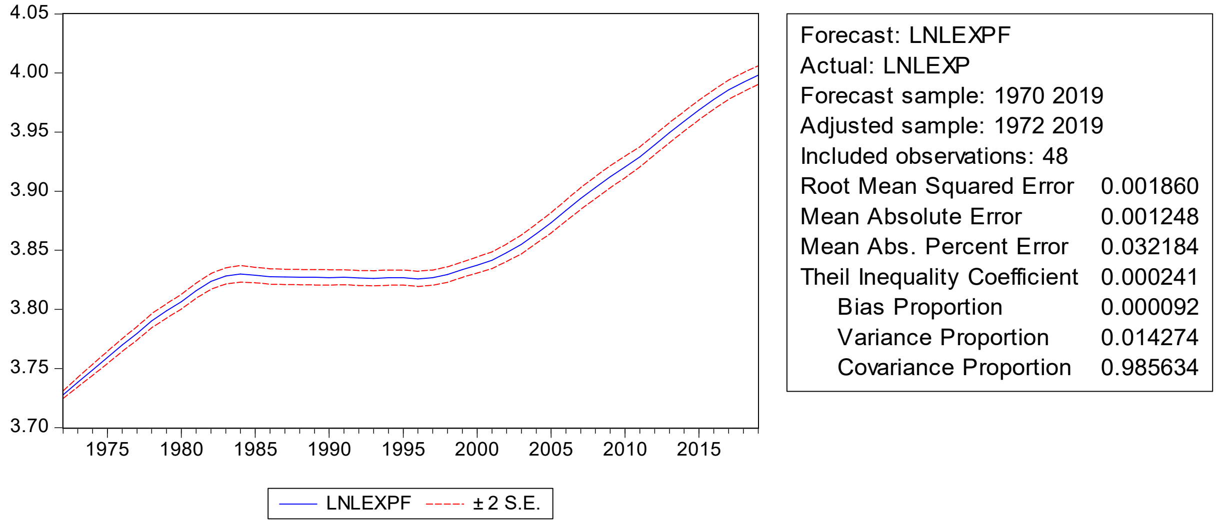

Figure 5. 3: Forecasting Life expectancy at birth in Nigeria

Source: Author's Computation (2021) *Using E-views 12*

5.10 Policy Implications of Findings

From the ARDL results, both Methane emissions, Carbon (iv) dioxide emissions, Nitrous Oxide emissions and real GDP per capita had significant bearing with Life expectancy at birth in the context of Nigeria in the period of assessment. The implication is that, for a desirable level of life expectancy to be achieved in the country, the government through stringent environmental regulations needs to pay close attention to the various human activities that generate these emission gases. The federal and state ministries of environment need to implement relevant environmental laws to ensure the regulation of all activities aimed at minimizing environmental emissions in the country.

Similarly, the use of various fiscal and monetary policy measures is required for promoting economic expansion and improve socioeconomic welfare of the citizenry. Thus, adequate attention needs to be invested to environmental emissions minimization in the process of health and environmental policy conception, design and execution in the country. In all, Methane emissions, Carbon (iv) dioxide emissions, Nitrous Oxide emissions and real GDP per capita are very influential for enhancing Life expectancy in Nigeria.

Specifically, the more Carbon (iv) dioxide emissions are released into the environment, the greater the human health negative effects. It therefore follows that as these emission gases are released into the atmosphere, there is a tendency that the human life span will be shortened, thus, reducing the total life expectancy in the country.

Also, the negative short run and long run coefficient of Methane emissions show that, as these gases are released into the atmosphere, they have the tendency to deteriorate the general health and wellbeing of individuals who are exposed to them. Since it is well established that these emission gases can live in the atmosphere of a long period of time, with the potential to cause harm through the release of airborne, there will be a progressive deterioration in human health occasioned by the constant release of these environmentally hostile gases, leading to a decline in Life expectancy at birth.

Just like Carbon (iv) dioxide emissions, the recurrent and unregulated release of Nitrous Oxide emissions into the ecosystem in the course of “agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater" will continue to exert a depressive effect on climate. Also, as these gases mixed with the atmospheric air, there will be a negative impact on the health and general wellbeing of individuals in the society in the course on respiration. This will exert negative implication for the life expectancy in the country as well.

The policy implication of the short run and long run positive coefficient of real GDP per capita is that, as the level of economic welfare in the country increases, individuals will have access to means of enhancing their livelihoods and take good care of their selves through healthy diet, good shelter and access to health care services which all have the tendency to boost their general health and wellbeing. When this occurs, the level of mortality will drop, thus, leading to improved human life span in the country.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Introduction

Recall that the general aim of this study was to empirically examine the effect of environmental emissions on Life expectancy in Nigeria, while the specific objectives include to examine the impact of Methane emissions, Carbon (iv) dioxide emissions, Nitrous Oxide emissions and real GDP per capita on Life expectancy at birth in Nigeria. The study covered the period spanning 1970 to 2019, using annual data set extracted from the United Nations World Population Prospects (Life expectancy at birth), the Global Carbon Project 2020 (Carbon (iv) dioxide emissions, Methane emissions, and Nitrous Oxide emissions) and World Bank (real GDP per capita).

The dependent variable was Life expectancy at birth, while the explanatory variables include Carbon (iv) dioxide emissions, Methane emissions, Nitrous Oxide emissions and real GDP per capita. Also, the method of analysis adopted in accomplishing the specific objectives of this study was the autoregressive distributed lag (ARDL) and bounds testing approach. Specifically, the short run and long run results were at the same time presented and discussed, while relevant policy inferences were drawn accordingly.

6.2 Summary of Findings

This section of the chapter presents the summary of both the preliminary and main findings of the study.

6.2.1 Preliminary Findings of the Study

(1) From the preliminary assessment of the descriptive properties of the variables employed in the study, it was ascertained that, Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita averaged 88.60 million tonnes, 73.75 million tonnes, 47.01years, 23.57 million tonnes and ₦27,380 respectively.

(2) Also, the result showed that from 1970 to 2019, Methane emissions accounted for a total of 4,429.77 million tonnes (highest volume of environmental emissions), while Carbon (iv) dioxide emissions represented a total of 3,687.33 million tonnes. Likewise, Nitrous Oxide emissions accounted for a total of 1,178.67 million tonnes in the same period of assessment.

(3) Similarly, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per capita were positively skewed, while Methane emissions was negatively skewed in the period of assessment.

(4) In the same vein, Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, Nitrous Oxide emissions and Real GDP per

capita were platykurtic in their distributions, suggestive of the presence of small outliers in the distributions.

(5) The Jarque-Bera statistic reveals that, all the series utilized in the study were normally distributed during the period of assessment.

6.2.2 Major Findings of the Study

The various principal findings from the ARDL estimation procedure are presented below.

(6) The coefficient of Carbon (iv) dioxide emissions and its associated one-period lag were both negative in the short run estimated results. However, it was positive in the long run. similarly, the result revealed that Carbon (iv) dioxide emissions and its associated one-period lag were statistically significant at 1% critical level in the long run and short run estimation results respectively.

(7) Similarly, the coefficient of Methane emissions was negative and statistically significant at 1% critical level in the short run estimation results, while its associated one-period lag was positive and statistically significant at 10% critical level in the short run estimation result in the period of assessment. Similarly, the result indicated that Methane emissions was negative and statistically significant at 1% critical level in the long run estimation results.

(8) Furthermore, the coefficient of Nitrous Oxide emissions was positive both in the short run and long run estimation results. The coefficient of its associated one-period lagged series became negative and statistically significant at 10% critical level in the short run estimation result in the period of assessment. The result further established that while the coefficient of Nitrous Oxide emissions was statistically significant at 10% critical level in the short run, it became statistically significant at 1% critical level in the long run.

(9) Similarly, the coefficient of real GDP per capita was positive both in the short run and long run estimation results in the period of assessment. Though, the coefficient of its associated one-period lagged series became negative and statistically significant at 1% critical level in the short run estimation result in the period of assessment. The result further established that while the coefficient of real GDP per capita was statistically insignificant in the short run, it was found to be statistically significant at 1% critical level in the long run estimation results.

6.3 Conclusion

The promotion of the general wellbeing of the citizens forms the core of environmental sustainability. However, through unguarded human activities such as transportation, agriculture, manufacturing, etc., harmful gases are released into the ecosystem. Also, through daily oil exploration, manufacturing activities, food and chemical processing and gas flaring human activities contribute to environmental pollutions on a daily basis. It has been acknowledged that in the process of agricultural cultivation, a number of farmers still adopt the traditional means such as bush burning, which triggers emissions gases to the atmosphere and these harmful gases are often inhaled by humans. This in turn exert unfavorable influence on the health of humans, thus leading to a decline in the human life span.

Most of these environmental hazards are created in the country's densely populated metropolises where lots of economic activities are carried out. In the light of the increasing level of economic activities in those urban areas, pollution accompanying the rising daily industrial and automobile emissions leads to both decreasing human life span. The effect of environmental emissions on Life expectancy at has been acknowledged both in industrialized and emerging economies. However, in the context of Nigeria, there is a need for urgent policy efforts to mitigate the deleterious effects of these hostile emission gases on human life span.

The study has been able to yet unveil this significant role the various greenhouse gases such as Methane emissions, Carbon (iv) dioxide emissions, Life expectancy at birth, and Nitrous Oxide emissions in the determination of life expectancy in the country. The study further re-established and validated previous findings on the effect of these emissions gases on Life expectancy. Again, improved human life span is believed to be a key area whereby the wider economy can be improved especially in terms of human capital advancement (improved health outcomes). Earlier research efforts have also recognized this role of GDP per capita in facilitating Life expectancy which in turn can lead to improvement in a nation's economic growth.

The deduction that can be made from this study is that both Methane emissions, Carbon (iv) dioxide emissions, Nitrous Oxide emissions and real GDP per capita exert significant effects on Life expectancy in the context of Nigeria. It therefore suggests that, if the country wants to boost its economic performance through its improved human life span, due recognition should be accorded to the variables employed in this study in the conception, formulation and implementation of environmental policy-led growth in the long-run.

6.4 Recommendations

Arising from the study's key empirical findings and conclusion drawn above, the following recommendations are offered for policy attention;

(1) Given the statistically significant negative relationship between Carbon (iv) dioxide emissions and Life expectancy in Nigeria, it is imperative for the country to adopt a stringent environmental control measures that will help reposition the country's environment through enhanced carbon control policy. This is hoped to help caution the unguarded activities exerted by human that leads to the release of Carbon (iv) dioxide emissions into the atmosphere. Specifically, it is recommended that Carbon Taxes should be introduced to help reduce the unwarranted industrial processes contributing a large volume of the total greenhouse gas emissions increase in the country. Thus, as the volume and rate of

Carbon (iv) dioxide emissions decline ceteris paribus, there will be an improvement t in the human life span in the country.

(2) The result also revealed that Methane emissions was negative and statistically significant both in the short run and long run. This is a worrisome situation implying that the level environmental regulation has not been encouraging specifically from the angle of government policy enforcements. To mitigate the negative effects of Methane emission gases, there is an urgent need to draft relevant policies to regulate all human activities that trigger the release of methane gases into the ecosystem especially in the area of production and transport of coal, natural gas, and oil, livestock and other agricultural practices, land use and by the decay of organic waste in municipal solid waste landfills. This policy should be decentralized to enable local and state governments implement the policy and further institute state and local monitoring teams to ensure unflinching compliance from the general public. the moribund environmental regulations should be reactivated to ensure the reduction of Methane emissions across the 774 local government areas in Nigeria.

(3) Furthermore, the coefficient of one-period lagged Nitrous Oxide emissions was negative in the period of assessment. It is therefore recommended that the government and all relevant stakeholders in the agricultural and industrial sectors to work collaboratively in ensuring that policy effort are implemented to limit the frequent release of

Nitrous oxide (N_2O) emission in the course of agricultural, land use, industrial activities, combustion of fossil fuels and solid waste, as well as during treatment of wastewater. In this regard, there is need for public enlightenment especially in the area of agricultural agricultural land use and the need to exercise extreme caution in the course of wastewater treatment.

(4) Given that the coefficient of real GDP per capita was positive both in the short run and long run, the study recommends the use of various fiscal and monetary policy measures to drive economic expansion and improve socioeconomic welfare of the citizenry. Specifically, the government through the monetary authorities should avail relevant credit avenues for investment to thrive as this will boost economic activities and output growth in the long run. As the size of the country's GDP grows, the level of GDP per capita will also improve, thus leading to a rise in economic welfare among the citizens.

6.5 Contribution to Knowledge

The various empirical findings of this study are indeed insightful. Specifically, this study has been able to establish both the short run and long run effects of Carbon (iv) dioxide emissions, Methane emissions, Nitrous Oxide emissions and real GDP per capita on Life expectancy in Nigeria. Thus, the various finding of this study will help widen the awareness of the general public, the government, management of various health institutions, environmental regulatory bodies and professionals. The results of this study will indeed facilitate the effectiveness of environmental management for improved life expectancy though adequate investment in environmental emission control.

Finally, the findings of this study will avail fresh information to advance future research in the area of investment in environmental management across the country and beyond. Though, previous studies only focused on the impact of Carbon (iv) dioxide emissions on Life expectancy, this study has contributed to the body of knowledge by further presenting the specific short run and long run effects of both Methane emissions and Nitrous Oxide emissions on life expectancy in the context of Nigeria.

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Appendices

Table 4.8: Data Used for Regression

year	Life expectancy at birth, total (years) (United Nations - World Population Prospects 2019)	Carbon (iv) dioxide emissions in Nigeria (million tonnes) the Global Carbon Project (2020)	Methane emissions (million tonnes) in Nigeria (1970-2019) the Global Carbon Project (2020)	Nitrous Oxide emissions (million tonnes) in Nigeria (1970 -2019) the Global Carbon Project (2020)	Real GDP per capita (N'000) World Bank (2020)
year	LEXP	CO_2	CH_4	N_2O	PCI
1970	40.79	21.52	35.20	11.47	25.55
1971	41.21	32.25	41.24	11.58	28.52
1972	41.62	41.39	46.79	11.61	28.79
1973	42.03	49.53	52.88	12.55	29.62
1974	42.48	62.24	59.25	11.80	32.09
1975	42.93	47.35	50.23	12.39	29.60
1976	43.39	55.19	54.86	13.08	31.36
1977	43.84	50.51	51.71	14.09	32.27
1978	44.29	48.22	51.40	13.56	29.50
1979	44.64	70.19	65.73	14.50	30.57
1980	44.98	68.04	61.76	16.24	30.96
1981	45.33	65.81	52.35	15.48	26.18
1982	45.67	65.39	50.42	16.38	23.77
1983	46.02	59.71	50.51	16.20	20.64
1984	46.01	69.41	52.73	16.39	19.90
1985	45.99	69.64	53.75	16.14	20.55
1986	45.98	73.19	54.00	16.53	20.03
1987	45.96	59.02	52.54	16.88	20.14
1988	45.95	70.42	56.55	17.20	21.05
1989	45.93	42.12	61.80	18.18	20.90
1990	45.92	38.86	114.03	20.79	22.77
1991	45.90	41.93	116.05	21.15	22.28
1992	45.89	46.27	116.93	21.51	22.73
1993	45.87	44.81	118.08	22.15	21.72
1994	45.90	34.93	120.10	22.58	20.80
1995	45.92	33.42	113.40	22.76	20.27
1996	45.95	36.79	115.87	26.21	20.60
1997	45.97	41.01	109.63	26.41	20.69
1998	46.00	37.75	105.92	28.50	20.70
1999	46.19	39.59	98.81	28.30	20.31

2000	46.38	78.82	93.72	28.94	20.80
2001	46.56	86.72	89.74	27.74	21.48
2002	46.75	94.31	92.40	27.81	24.16
2003	46.94	100.01	96.24	28.94	25.28
2004	47.50	98.69	99.15	28.51	26.92
2005	48.07	105.76	104.16	31.27	27.92
2006	48.63	97.81	104.83	30.86	28.85
2007	49.20	94.27	105.05	30.18	29.96
2008	49.76	94.77	106.13	30.75	31.15
2009	50.20	74.89	104.28	29.41	32.76
2010	50.64	112.31	107.77	31.71	34.45
2011	51.07	129.57	112.40	32.36	35.33
2012	51.51	116.33	116.41	33.22	35.85
2013	51.95	122.10	118.90	33.96	37.23
2014	52.40	127.82	121.37	34.31	38.53
2015	52.84	113.54	124.08	34.67	38.52
2016	53.29	116.77	133.82	37.39	36.92
2017	53.73	130.28	134.46	37.20	36.26
2018	54.18	136.08	138.26	38.01	36.01
2019	54.49	140.03	142.07	38.82	35.87

Unit Root Test

Augmented Dickey-Fuller Test

LEVEL

Null Hypothesis: LNCH4 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on t-statistic, lagpval=0.1, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.745405	0.4026
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNCH4)
Method: Least Squares
Date: 08/25/21 Time: 23:05
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCH4(-1)	-0.069816	0.040000	-1.745405	0.0874
C	0.335772	0.176741	1.899793	0.0636

R-squared	0.060872	Mean dependent var	0.028476
Adjusted R-squared	0.040891	S.D. dependent var	0.110832
S.E. of regression	0.108542	Akaike info criterion	-1.563395
Sum squared resid	0.553726	Schwarz criterion	-1.486178
Log likelihood	40.30318	Hannan-Quinn criter.	-1.534099
F-statistic	3.046438	Durbin-Watson stat	1.743647
Prob(F-statistic)	0.087450		

Null Hypothesis: LNCO2 has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on t-statistic, lagpval=0.1, maxlag=0)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-2.128991	0.2346
Test critical values: 1% level	-3.571310	
5% level	-2.922449	
10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNCO2)
Method: Least Squares
Date: 08/25/21 Time: 23:13
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCO2(-1)	-0.124284	0.058377	-2.128991	0.0385
C	0.558108	0.245628	2.272164	0.0277

R-squared	0.087956	Mean dependent var	0.038221
Adjusted R-squared	0.068551	S.D. dependent var	0.192259
S.E. of regression	0.185552	Akaike info criterion	-0.491004
Sum squared resid	1.618188	Schwarz criterion	-0.413787
Log likelihood	14.02959	Hannan-Quinn criter.	-0.461708
F-statistic	4.532602	Durbin-Watson stat	1.918939
Prob(F-statistic)	0.038524		

Null Hypothesis: LNLEXP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on t-statistic, lagpval=0.1, maxlag=0)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	0.527453	0.9860
Test critical values: 1% level	-3.571310	
5% level	-2.922449	
10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNLEXP)
Method: Least Squares
Date: 08/25/21 Time: 23:16
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLEXP(-1)	0.004895	0.009280	0.527453	0.6004
C	-0.012909	0.035684	-0.361767	0.7191

R-squared	0.005884	Mean dependent var	0.005909
Adjusted R-squared	-0.015267	S.D. dependent var	0.004453
S.E. of regression	0.004486	Akaike info criterion	-7.935561
Sum squared resid	0.000946	Schwarz criterion	-7.858344
Log likelihood	196.4212	Hannan-Quinn criter.	-7.906265
F-statistic	0.278207	Durbin-Watson stat	0.168144
Prob(F-statistic)	0.600360		

Null Hypothesis: LNN2O has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.990262	0.7495
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNN2O)
Method: Least Squares
Date: 08/25/21 Time: 23:29
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNN2O(-1)	-0.016841	0.017007	-0.990262	0.3273
D(LNN2O(-1))	-0.292206	0.140859	-2.074460	0.0438
C	0.084583	0.053090	1.593213	0.1181

R-squared	0.104913	Mean dependent var	0.025209
Adjusted R-squared	0.065131	S.D. dependent var	0.044916
S.E. of regression	0.043428	Akaike info criterion	-3.374942
Sum squared resid	0.084871	Schwarz criterion	-3.257992
Log likelihood	83.99860	Hannan-Quinn criter.	-3.330746
F-statistic	2.637209	Durbin-Watson stat	2.012225
Prob(F-statistic)	0.082599		

Null Hypothesis: LNPCI has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.807385	0.8079
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNPCI)
Method: Least Squares
Date: 08/25/21 Time: 23:31
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPCI(-1)	-0.028463	0.035253	-0.807385	0.4237
D(LNPCI(-1))	0.315782	0.138859	2.274111	0.0278
C	0.095890	0.115695	0.828817	0.4116

R-squared	0.105235	Mean dependent var	0.004777
Adjusted R-squared	0.065468	S.D. dependent var	0.054530

S.E. of regression	0.052715	Akaike info criterion	-2.987369
Sum squared resid	0.125050	Schwarz criterion	-2.870419
Log likelihood	74.69686	Hannan-Quinn criter.	-2.943174
F-statistic	2.646271	Durbin-Watson stat	2.118705
Prob(F-statistic)	0.081931		

Augmented Dickey-Fuller Test

FIRST DIFFERENCE

Null Hypothesis: D(LNCH4) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on t-statistic, lagpval=0.1, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.185863	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNCH4,2)
Method: Least Squares
Date: 08/25/21 Time: 23:07
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCH4(-1))	-0.893312	0.144412	-6.185863	0.0000
C	0.022725	0.016526	1.375087	0.1758

R-squared	0.454103	Mean dependent var	-0.002738
Adjusted R-squared	0.442235	S.D. dependent var	0.148478
S.E. of regression	0.110889	Akaike info criterion	-1.519805
Sum squared resid	0.565630	Schwarz criterion	-1.441838
Log likelihood	38.47532	Hannan-Quinn criter.	-1.490341
F-statistic	38.26491	Durbin-Watson stat	2.029931
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNCO2) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on t-statistic, lagpval=0.1, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-7.308039	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNCO2,2)
Method: Least Squares
Date: 08/25/21 Time: 23:12
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2(-1))	-1.034429	0.141547	-7.308039	0.0000
C	0.031911	0.027751	1.149917	0.2561

R-squared	0.537258	Mean dependent var	-0.007833
Adjusted R-squared	0.527198	S.D. dependent var	0.274192
S.E. of regression	0.188536	Akaike info criterion	-0.458279
Sum squared resid	1.635112	Schwarz criterion	-0.380313
Log likelihood	12.99870	Hannan-Quinn criter.	-0.428815
F-statistic	53.40743	Durbin-Watson stat	2.073807
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNLEXP) has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

	t-Statistic	Prob.*

Augmented Dickey-Fuller test statistic		-4.544270	0.0006
Test critical values:	1% level	-3.581152	
	5% level	-2.926622	
	10% level	-2.601424	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNLEXP,2)
Method: Least Squares
Date: 08/25/21 Time: 23:21
Sample (adjusted): 1974 2019
Included observations: 46 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNLEXP(-1))	-0.998864	0.219807	-4.544270	0.0000
D(LNLEXP(-1),2)	-0.000670	0.155424	-0.004312	0.9966
C	-8.85E-05	0.000282	-0.313416	0.7555

R-squared	0.490262	Mean dependent var	-5.19E-05
Adjusted R-squared	0.466553	S.D. dependent var	0.002621
S.E. of regression	0.001914	Akaike info criterion	-9.616286
Sum squared resid	0.000158	Schwarz criterion	-9.497027
Log likelihood	224.1746	Hannan-Quinn criter.	-9.571611
F-statistic	20.67854	Durbin-Watson stat	1.957822
Prob(F-statistic)	0.000001		

Null Hypothesis: D(LNN2O) has a unit root
Exogenous: Constant
Lag Length: 1 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.399332	0.0000
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNN2O,2)
Method: Least Squares
Date: 08/25/21 Time: 23:29
Sample (adjusted): 1973 2019
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNN2O(-1))	-1.302439	0.241222	-5.399332	0.0000
D(LNN2O(-1),2)	0.004634	0.149941	0.030908	0.9755
C	0.033332	0.008856	3.763925	0.0005

R-squared	0.649523	Mean dependent var	0.000387
Adjusted R-squared	0.633592	S.D. dependent var	0.073028
S.E. of regression	0.044205	Akaike info criterion	-3.338249
Sum squared resid	0.085980	Schwarz criterion	-3.220154
Log likelihood	81.44884	Hannan-Quinn criter.	-3.293809
F-statistic	40.77164	Durbin-Watson stat	1.946019
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNPCI) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.440411	0.0002
Test critical values:	1% level	-4.161144	
	5% level	-3.506374	
	10% level	-3.183002	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNPCI,2)
Method: Least Squares
Date: 08/25/21 Time: 23:32
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPCI(-1))	-0.740444	0.136101	-5.440411	0.0000
C	-0.016665	0.015786	-1.055636	0.2968
@TREND("1970")	0.000768	0.000550	1.396451	0.1694

R-squared	0.398422	Mean dependent var	-0.002369
Adjusted R-squared	0.371685	S.D. dependent var	0.065578
S.E. of regression	0.051981	Akaike info criterion	-3.015409
Sum squared resid	0.121592	Schwarz criterion	-2.898459
Log likelihood	75.36982	Hannan-Quinn criter.	-2.971214
F-statistic	14.90164	Durbin-Watson stat	2.096123
Prob(F-statistic)	0.000011		

Phillips-Perron Test

LEVEL

Null Hypothesis: LNCH4 has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.758380	0.3963
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.011301
HAC corrected variance (Bartlett kernel)	0.012684

Phillips-Perron Test Equation
Dependent Variable: D(LNCH4)
Method: Least Squares
Date: 08/25/21 Time: 23:08
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCH4(-1)	-0.069816	0.040000	-1.745405	0.0874
C	0.335772	0.176741	1.899793	0.0636

R-squared	0.060872	Mean dependent var	0.028476
Adjusted R-squared	0.040891	S.D. dependent var	0.110832
S.E. of regression	0.108542	Akaike info criterion	-1.563395
Sum squared resid	0.553726	Schwarz criterion	-1.486178
Log likelihood	40.30318	Hannan-Quinn criter.	-1.534099
F-statistic	3.046438	Durbin-Watson stat	1.743647
Prob(F-statistic)	0.087450		

Null Hypothesis: LNCO2 has a unit root
Exogenous: Constant
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.182273	0.2151
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.033024
HAC corrected variance (Bartlett kernel)	0.038075

Phillips-Perron Test Equation
Dependent Variable: D(LNCO2)
Method: Least Squares
Date: 08/25/21 Time: 23:12
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCO2(-1)	-0.124284	0.058377	-2.128991	0.0385
C	0.558108	0.245628	2.272164	0.0277

R-squared	0.087956	Mean dependent var	0.038221
Adjusted R-squared	0.068551	S.D. dependent var	0.192259
S.E. of regression	0.185552	Akaike info criterion	-0.491004
Sum squared resid	1.618188	Schwarz criterion	-0.413787
Log likelihood	14.02959	Hannan-Quinn criter.	-0.461708
F-statistic	4.532602	Durbin-Watson stat	1.918939
Prob(F-statistic)	0.038524		

Null Hypothesis: LNLEXP has a unit root
Exogenous: Constant
Bandwidth: 5 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.152595	0.9374
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	1.93E-05
HAC corrected variance (Bartlett kernel)	9.43E-05

Phillips-Perron Test Equation
Dependent Variable: D(LNLEXP)
Method: Least Squares
Date: 08/25/21 Time: 23:24
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLEXP(-1)	0.004895	0.009280	0.527453	0.6004
C	-0.012909	0.035684	-0.361767	0.7191

R-squared	0.005884	Mean dependent var	0.005909
Adjusted R-squared	-0.015267	S.D. dependent var	0.004453
S.E. of regression	0.004486	Akaike info criterion	-7.935561

Sum squared resid	0.000946	Schwarz criterion	-7.858344
Log likelihood	196.4212	Hannan-Quinn criter.	-7.906265
F-statistic	0.278207	Durbin-Watson stat	0.168144
Prob(F-statistic)	0.600360		

Null Hypothesis: LNN2O has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-0.866754	0.7905
Test critical values:	1% level	-3.571310	
	5% level	-2.922449	
	10% level	-2.599224	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.001911
HAC corrected variance (Bartlett kernel)	0.001258

Phillips-Perron Test Equation
Dependent Variable: D(LNN2O)
Method: Least Squares
Date: 08/25/21 Time: 23:28
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNN2O(-1)	-0.014273	0.016947	-0.842178	0.4040
C	0.068829	0.052571	1.309260	0.1968

R-squared	0.014866	Mean dependent var	0.024882
Adjusted R-squared	-0.006094	S.D. dependent var	0.044504
S.E. of regression	0.044640	Akaike info criterion	-3.340419
Sum squared resid	0.093658	Schwarz criterion	-3.263201
Log likelihood	83.84026	Hannan-Quinn criter.	-3.311122
F-statistic	0.709264	Durbin-Watson stat	2.582786
Prob(F-statistic)	0.403954		

Null Hypothesis: LNPCI has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.211147	0.8970
Test critical values:	1% level	-4.156734	
	5% level	-3.504330	
	10% level	-3.181826	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.002948
HAC corrected variance (Bartlett kernel)	0.005642

Phillips-Perron Test Equation
Dependent Variable: D(LNPCI)
Method: Least Squares
Date: 08/25/21 Time: 23:33
Sample (adjusted): 1971 2019
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPCI(-1)	-0.032350	0.039195	-0.825372	0.4134
C	0.092685	0.124266	0.745858	0.4595
@TREND("1970")	0.000813	0.000605	1.344062	0.1855

R-squared	0.040604	Mean dependent var	0.006922
Adjusted R-squared	-0.001109	S.D. dependent var	0.056010
S.E. of regression	0.056041	Akaike info criterion	-2.866200
Sum squared resid	0.144467	Schwarz criterion	-2.750374
Log likelihood	73.22189	Hannan-Quinn criter.	-2.822255
F-statistic	0.973421	Durbin-Watson stat	1.355411
Prob(F-statistic)	0.385434		

Phillips-Perron Test

FIRST DIFFERENCE

Null Hypothesis: D(LNCH4) has a unit root
Exogenous: Constant
Bandwidth: 2 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.176895	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.011784
HAC corrected variance (Bartlett kernel)	0.011406

Phillips-Perron Test Equation
Dependent Variable: D(LNCH4,2)
Method: Least Squares
Date: 08/25/21 Time: 23:09
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCH4(-1))	-0.893312	0.144412	-6.185863	0.0000
C	0.022725	0.016526	1.375087	0.1758

R-squared	0.454103	Mean dependent var	-0.002738
Adjusted R-squared	0.442235	S.D. dependent var	0.148478
S.E. of regression	0.110889	Akaike info criterion	-1.519805
Sum squared resid	0.565630	Schwarz criterion	-1.441838
Log likelihood	38.47532	Hannan-Quinn criter.	-1.490341
F-statistic	38.26491	Durbin-Watson stat	2.029931
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNCO2) has a unit root
Exogenous: Constant
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-7.328763	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.034065
HAC corrected variance (Bartlett kernel)	0.032250

Phillips-Perron Test Equation
Dependent Variable: D(LNCO2,2)
Method: Least Squares
Date: 08/25/21 Time: 23:11
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2(-1))	-1.034429	0.141547	-7.308039	0.0000
C	0.031911	0.027751	1.149917	0.2561

R-squared	0.537258	Mean dependent var	-0.007833
Adjusted R-squared	0.527198	S.D. dependent var	0.274192
S.E. of regression	0.188536	Akaike info criterion	-0.458279
Sum squared resid	1.635112	Schwarz criterion	-0.380313
Log likelihood	12.99870	Hannan-Quinn criter.	-0.428815
F-statistic	53.40743	Durbin-Watson stat	2.073807
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNLEXP) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-6.578860	0.0000
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	3.35E-06
HAC corrected variance (Bartlett kernel)	3.35E-06

Phillips-Perron Test Equation
Dependent Variable: D(LNLEXP,2)
Method: Least Squares
Date: 08/25/21 Time: 23:25
Sample (adjusted): 1973 2019
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNLEXP(-1))	-0.999530	0.151931	-6.578860	0.0000
C	-8.87E-05	0.000273	-0.324978	0.7467

R-squared	0.490266	Mean dependent var	-5.08E-05
Adjusted R-squared	0.478939	S.D. dependent var	0.002592
S.E. of regression	0.001871	Akaike info criterion	-9.683120
Sum squared resid	0.000158	Schwarz criterion	-9.604390
Log likelihood	229.5533	Hannan-Quinn criter.	-9.653493
F-statistic	43.28140	Durbin-Watson stat	1.963484
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNN2O) has a unit root
Exogenous: Constant
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

	Adj. t-Stat	Prob.*

Phillips-Perron test statistic		-9.173411	0.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.001807
HAC corrected variance (Bartlett kernel)	0.001807

Phillips-Perron Test Equation
Dependent Variable: D(LNN2O,2)
Method: Least Squares
Date: 08/25/21 Time: 23:27
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNN2O(-1))	-1.291879	0.140829	-9.173411	0.0000
C	0.032494	0.007185	4.522229	0.0000

R-squared	0.646566	Mean dependent var	0.000250
Adjusted R-squared	0.638882	S.D. dependent var	0.072253
S.E. of regression	0.043419	Akaike info criterion	-3.395051
Sum squared resid	0.086721	Schwarz criterion	-3.317084
Log likelihood	83.48122	Hannan-Quinn criter.	-3.365587
F-statistic	84.15146	Durbin-Watson stat	2.003168
Prob(F-statistic)	0.000000		

Null Hypothesis: D(LNPCI) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-5.513127	0.0002
Test critical values:	1% level	-4.161144	
	5% level	-3.506374	
	10% level	-3.183002	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.002533
HAC corrected variance (Bartlett kernel)	0.002902

Phillips-Perron Test Equation
Dependent Variable: D(LNPCI,2)
Method: Least Squares
Date: 08/25/21 Time: 23:34
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNPCI(-1))	-0.740444	0.136101	-5.440411	0.0000
C	-0.016665	0.015786	-1.055636	0.2968
@TREND("1970")	0.000768	0.000550	1.396451	0.1694

R-squared	0.398422	Mean dependent var	-0.002369
Adjusted R-squared	0.371685	S.D. dependent var	0.065578
S.E. of regression	0.051981	Akaike info criterion	-3.015409
Sum squared resid	0.121592	Schwarz criterion	-2.898459
Log likelihood	75.36982	Hannan-Quinn criter.	-2.971214
F-statistic	14.90164	Durbin-Watson stat	2.096123
Prob(F-statistic)	0.000011		

ARDL Bounds Test

ARDL Bounds Test
Date: 08/25/21 Time: 22:19
Sample: 1972 2019
Included observations: 48
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	70.50310	4

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

Test Equation:
Dependent Variable: D(LNLEXP)
Method: Least Squares
Date: 08/25/21 Time: 22:19
Sample: 1972 2019
Included observations: 48

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2)	-0.000538	0.001548	-0.347366	0.7305
D(LNCO2(-1))	-0.003318	0.001363	-2.433773	0.0203
D(LNCH4)	-0.004458	0.003028	-1.472427	0.1501
D(LNCH4(-1))	0.004593	0.002868	1.601538	0.1185
D(LNN2O)	0.003827	0.005935	0.644834	0.5234
D(LNN2O(-1))	-0.005046	0.005893	-0.856395	0.3978
D(LNPCI)	0.003246	0.005899	0.550205	0.5858
D(LNPCI(-1))	-0.016441	0.005849	-2.810835	0.0081
C	0.337748	0.040148	8.412558	0.0000
LNCO2(-1)	0.002991	0.001565	1.911572	0.0644
LNCH4(-1)	-0.008293	0.002338	-3.546816	0.0012
LNN2O(-1)	0.021976	0.003339	6.581321	0.0000

LNPCI(-1)	0.023328	0.001728	13.49678	0.0000
LNLEXP(-1)	-0.117498	0.012833	-9.155730	0.0000

R-squared	0.923314	Mean dependent var	0.005823
Adjusted R-squared	0.893992	S.D. dependent var	0.004458
S.E. of regression	0.001452	Akaike info criterion	-9.993925
Sum squared resid	7.16E-05	Schwarz criterion	-9.448158
Log likelihood	253.8542	Hannan-Quinn criter.	-9.787679
F-statistic	31.48959	Durbin-Watson stat	1.650574
Prob(F-statistic)	0.000000		

ARDL Cointegrating And Long Run Form

ARDL Cointegrating And Long Run Form
Dependent Variable: LNLEXP
Selected Model: ARDL(1, 2, 2, 2, 2)
Date: 08/25/21 Time: 22:26
Sample: 1970 2019
Included observations: 48

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2)	-0.000538	0.001066	-0.504529	0.6171
D(LNCO2(-1))	-0.003318	0.001129	-2.939343	0.0059
D(LNCH4)	-0.004458	0.001297	-3.437197	0.0016
D(LNCH4(-1))	0.004593	0.002383	1.927907	0.0623
D(LNN2O)	0.003827	0.002552	1.499814	0.1429
D(LNN2O(-1))	-0.005046	0.003305	-1.527006	0.1360
D(LNPCI)	0.003246	0.003520	0.922003	0.3630
D(LNPCI(-1))	-0.016441	0.005431	-3.027091	0.0047
CointEq(-1)	-0.117498	0.013500	-8.703663	0.0000

Cointeq = LNLEXP - (0.0255*LNCO2 -0.0706*LNCH4 + 0.1870 *LNN2O + 0.1985*LNPCI + 2.8745)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCO2	0.025459	0.007287	3.493749	0.0013
LNCH4	-0.070577	0.010604	-6.655718	0.0000
LNN2O	0.187032	0.014157	13.211520	0.0000
LNPCI	0.198538	0.019679	10.088731	0.0000
C	2.874488	0.040697	70.631115	0.0000

Dependent Variable: LNLEXP
Method: ARDL
Date: 08/25/21 Time: 22:29
Sample (adjusted): 1972 2019
Included observations: 48 after adjustments
Dependent lags: 1 (Fixed)
Dynamic regressors (2 lags, fixed): LNCO2 LNCH4 LNN2O
LNPCI

Fixed regressors: C
HAC standard errors & covariance (Bartlett kernel, Newey-West
automatic
bandwidth = 10.1395 (with offset=7), NW automatic lag length =
3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNLEXP(-1)	0.882502	0.013058	67.58203	0.0000
LNCO2	-0.000538	0.000986	-0.545385	0.5890
LNCO2(-1)	0.000211	0.000886	0.238289	0.8131
LNCO2(-2)	0.003318	0.001098	3.023208	0.0047
LNCH4	-0.004458	0.001237	-3.604875	0.0010
LNCH4(-1)	0.000759	0.002444	0.310415	0.7581
LNCH4(-2)	-0.004593	0.002345	-1.958590	0.0584
LNN2O	0.003827	0.002205	1.735740	0.0917
LNN2O(-1)	0.013102	0.003041	4.308751	0.0001
LNN2O(-2)	0.005046	0.002959	1.705294	0.0973
LNPCI	0.003246	0.003170	1.024046	0.3130
LNPCI(-1)	0.003641	0.005667	0.642371	0.5249
LNPCI(-2)	0.016441	0.005056	3.252014	0.0026
C	0.337748	0.040840	8.269999	0.0000

R-squared	0.999673	Mean dependent var	3.853425
Adjusted R-squared	0.999548	S.D. dependent var	0.068288
S.E. of regression	0.001452	Akaike info criterion	-9.993925
Sum squared resid	7.16E-05	Schwarz criterion	-9.448158
Log likelihood	253.8542	Hannan-Quinn criter.	-9.787679
F-statistic	7999.325	Durbin-Watson stat	1.650574
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Ramsey RESET Test

Ramsey RESET Test
Equation: UNTITLED
Specification: LNLEXP LNLEXP(-1) LNCO2 LNCO2(-1) LNCO2(-2)
LNCH4 LNCH4(-1) LNCH4(-2) LNN2O LNN2O(-1) LNN2O(-2)
LNPCI LNPCI(-1) LNPCI(-2) C
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.345458	33	0.7319
F-statistic	0.119341	(1, 33)	0.7319

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	2.58E-07	1	2.58E-07
Restricted SSR	7.16E-05	34	2.11E-06
Unrestricted SSR	7.14E-05	33	2.16E-06

Unrestricted Test Equation:
Dependent Variable: LNLEXP
Method: ARDL
Date: 08/25/21 Time: 22:34
Sample: 1972 2019
Included observations: 48
Dependent lags: 1 (Fixed)
Dynamic regressors (2 lags, fixed):
Fixed regressors: C
HAC standard errors & covariance (Bartlett kernel, Newey-West automatic
bandwidth = 9.8974 (with offset=7), NW automatic lag length = 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNLEXP(-1)	1.054451	0.423712	2.488603	0.0180
LNCO2	-0.000656	0.001073	-0.611149	0.5453
LNCO2(-1)	0.000259	0.000817	0.317245	0.7531
LNCO2(-2)	0.003722	0.002077	1.792099	0.0823

LNCH4	-0.005135	0.002562	-2.004248	0.0533
LNCH4(-1)	0.000721	0.002463	0.292898	0.7714
LNCH4(-2)	-0.005524	0.004146	-1.332315	0.1919
LNN2O	0.004083	0.002539	1.608283	0.1173
LNN2O(-1)	0.015537	0.007731	2.009813	0.0527
LNN2O(-2)	0.006420	0.004595	1.397102	0.1717
LNPCI	0.004083	0.003926	1.039860	0.3060
LNPCI(-1)	0.004657	0.005488	0.848613	0.4022
LNPCI(-2)	0.019601	0.011801	1.660993	0.1062
C	0.023600	0.764129	0.030884	0.9755
FITTED^2	-0.024946	0.062770	-0.397421	0.6936

R-squared	0.999674	Mean dependent var	3.853425
Adjusted R-squared	0.999536	S.D. dependent var	0.068288
S.E. of regression	0.001471	Akaike info criterion	-9.955868
Sum squared resid	7.14E-05	Schwarz criterion	-9.371118
Log likelihood	253.9408	Hannan-Quinn criter.	-9.734890
F-statistic	7235.556	Durbin-Watson stat	1.640365
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Breusch-Godfrey Serial Correlation LM Test:

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.958674	Prob. F(2,32)	0.3941
Obs*R-squared	2.713441	Prob. Chi-Square(2)	0.2575

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 08/25/21 Time: 22:42
Sample: 1972 2019
Included observations: 48
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLEXP(-1)	0.001581	0.013194	0.119852	0.9054
$LNCO_2$	-0.000356	0.001640	-0.217175	0.8295
$LNCO_2(-1)$	-7.94E-05	0.001837	-0.043217	0.9658

$LNCO_2(-2)$	7.01E-05	0.001366	0.051305	0.9594
$LNCH_4$	-0.000466	0.003118	-0.149367	0.8822
$LNCH_4(-1)$	0.000215	0.003879	0.055528	0.9561
$LNCH_4(-2)$	8.52E-06	0.002872	0.002969	0.9976
LNN_2O	-0.001173	0.006077	-0.193019	0.8482
$LNN_2O(-1)$	0.001054	0.006447	0.163567	0.8711
$LNN_2O(-2)$	0.000164	0.005905	0.027734	0.9780
LNPCI	0.002700	0.006748	0.400171	0.6917
LNPCI(-1)	-0.002903	0.009358	-0.310252	0.7584
LNPCI(-2)	0.000476	0.005875	0.080969	0.9360
C	-0.004470	0.041128	-0.108687	0.9141
RESID(-1)	0.200567	0.175399	1.143489	0.2613
RESID(-2)	-0.198873	0.208422	-0.954184	0.3471

R-squared	0.056530	Mean dependent var	-1.04E-15
Adjusted R-squared	-0.385722	S.D. dependent var	0.001235
S.E. of regression	0.001453	Akaike info criterion	-9.968782
Sum squared resid	6.76E-05	Schwarz criterion	-9.345048
Log likelihood	255.2508	Hannan-Quinn criter.	-9.733072
F-statistic	0.127823	Durbin-Watson stat	1.943632
Prob(F-statistic)	0.999940		

Heteroskedasticity Test: Breusch-Pagan-Godfrey

Heteroskedasticity Test: Harvey

F-statistic	1.332742	Prob. F(13,34)	0.2428
Obs*R-squared	16.20303	Prob. Chi-Square(13)	0.2383
Scaled explained SS	24.50432	Prob. Chi-Square(13)	0.0268

Test Equation:
Dependent Variable: LRESID2
Method: Least Squares
Date: 08/25/21 Time: 22:44
Sample: 1972 2019
Included observations: 48
HAC standard errors & covariance (Bartlett kernel, Newey-West automatic
bandwidth = 19.5993 (with offset=7), NW automatic lag length = 3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	146.8903	24.61485	5.967548	0.0000
LNLEXP(-1)	-51.13600	8.846446	-5.780400	0.0000

LNCO2	0.410773	1.816711	0.226108	0.8225
$LNCO_2(-1)$	-2.565764	2.621049	-0.978907	0.3345
$LNCO_2(-2)$	3.353895	1.321139	2.538639	0.0159
$LNCH_4$	0.600787	5.116941	0.117411	0.9072
$LNCH_4(-1)$	-0.587044	7.675780	-0.076480	0.9395
$LNCH_4(-2)$	-6.742886	3.434424	-1.963324	0.0578
LNN_2O	0.926103	16.05563	0.057681	0.9543
$LNN_2O(-1)$	-3.615834	16.31497	-0.221627	0.8259
$LNN_2O(-2)$	18.46894	6.148939	3.003598	0.0050
LNPCI	-16.30500	7.828705	-2.082720	0.0449
LNPCI(-1)	16.94122	9.500608	1.783172	0.0835
LNPCI(-2)	2.646782	6.868412	0.385356	0.7024

R-squared	0.337563	Mean dependent var	-15.43103
Adjusted R-squared	0.084278	S.D. dependent var	2.760767
S.E. of regression	2.641871	Akaike info criterion	5.019344
Sum squared resid	237.3023	Schwarz criterion	5.565111
Log likelihood	-106.4643	Hannan-Quinn criter.	5.225590
F-statistic	1.332742	Durbin-Watson stat	1.856649
Prob(F-statistic)	0.242836		