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Effect of climate change and global warming on longevity: Empirical evidence from Nigeria

Ayeleso Anthony Olusoji*

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Author Affiliation:
ACETEL, National Open University of Nigeria, Abuja, Nigeria

***Corresponding author**
ACETEL, National Open University of Nigeria,
Abuja, Nigeria
Email: oayeleso@noun.edu.ng

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ABSTRACT

The effects of climate change and global warming are having a significant impact on the environment, cultures, and economies all across the world. These issues are now among the most pressing of our time. This study investigates the impact of climate change and global warming on longevity in Nigeria from 1970 to 2022. The data was sourced from the World Development Indicators (WDI) and the Autoregressive Distributed Lags (ARDL) estimation method was used. The results show that all independent variables significantly reduce longevity in Nigeria, consistent with previous studies. The Wald test and p-value were used to evaluate the five hypotheses and find to reduce longevity in Nigeria significantly. If policymakers intervene by 1% in the independent variables, they can improve longevity by 23.3% in one year. This suggests that policymakers must consider future climate change and global warming patterns in Nigeria to develop longevity policies that ensure a sustainable long life for citizens.

Keywords: Climate change, global warming, longevity

1. INTRODUCTION

A long-term transformation of Earth's typical weather patterns, including changes in temperature, precipitation, and other climatic variables, is referred to as climate change. Global warming, which particularly refers to the rise in Earth's average surface temperature brought on by human activity, is one of the main causes of current climate change. By increasing the natural greenhouse effect and warming the earth, the burning of fossil fuels, deforestation, and different industrial operations have released greenhouse gases into the atmosphere. We've seen it in the past few weeks as temperatures hit record highs around the world - both in the Northern Hemisphere and the warm Australian winter. Global warming is caused by humanity's greenhouse gas emissions, which continue at nearly record pace and are primarily produced by people in the world's wealthiest regions. Given that these phenomena cut beyond both cultural and geographical boundaries, it is crucial to comprehend the effects of climate change and global warming.

Beyond just changing the environment, the effects also have an impact on ecosystems, economies, and the welfare of both present and future generations. We can predict problems and develop efficient measures for mitigation and adaptation by thoroughly examining these impacts. We can calculate the possible

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risks brought on by increasing temperatures, changing precipitation patterns, and more frequent and severe extreme weather events through careful research and analysis. Such information is crucial for developing policies that defend agriculture, provide water security, and defend vulnerable populations. We arm ourselves with the information necessary to build sustainable solutions that promote resilience and slow down the further acceleration of these phenomena by exploring the origins and effects of climate change. Table 1 illustrates the progressive rise in global temperatures since 1880, highlighting the acceleration of global warming.

Table 1 Global Temperature Increase Over Time

Year	Average Global Temperature Increase (°C)
1880	+0.0
1900	+0.2
1950	+0.6
2000	+1.0
2023	+1.2 (Projected)

Nigeria has three distinct climate zones: A tropical savannah climate throughout most of the middle areas, a tropical monsoon climate in the south, and a hot, semi-arid Sahelian climate in the north. As a result, precipitation levels decrease from south to north along a gradient. Strong rainfall events occur often in the southern parts of the country throughout the rainy season, which lasts from March to October (Chukwuma et al., 2023). Annual rainfall amounts in the region are typically above 2,000 mm and can exceed 4,000 mm in the Niger Delta. A single, clearly defined wet season (April to September) and dry season (December to March) control the central areas. The Harmattan wind from the Sahara has an impact on the dry season. In coastal areas, there is a brief dry season, with the majority of the rain falling from March to October. Rainfall on average each year might be as high as 1200 mm. Only 500 to 750 mm of rain, or less, falls in the north from June to September. It's hot and dry for the remainder of the year. The significant degree of annual variation in rainfall in northern regions causes flooding and droughts.

Nigeria's coastal regions and interior, as well as the plateau and lowlands, have the largest temperature differences. In contrast to the central lowlands, where temperatures are typically above 27°C, the mean annual temperature on the plateau is between 21°C and 27°C. Compared to the inner lowlands, the coastal fringes have fewer resources. The national average seasonal temperature is consistently over 20°C, and daily differences are more noticeable than seasonal variations. The hottest temperatures take place during the dry season and don't significantly differ from coastal to interior regions. In Nigeria, relative humidity also declines from south to north, with a typical yearly value of 88% in the area around Lagos. The mean annual temperature for Nigeria is 26.9°C, with average monthly temperatures ranging between 24°C (December and January) and 30°C (April). The mean annual precipitation is 1,165.0 mm. Rainfall is experienced throughout the year in Nigeria, with the most significant rainfall occurring from April to October and minimal rainfall occurring from November to March.

Nigeria had a death rate of 56.68 for newborns under one year old as of 2022. According to this, there were roughly 56 infant deaths for every 1,000 live births. Africa has extraordinarily high rates of child mortality. Nearly all of the nations in the world with the highest infant mortality rates are African nations. The rates of maternal mortality are very high. Nigeria experienced 917 maternal deaths for every 100,000 live births in 2017. Therefore, it is crucial to investigate the many facets of climate change and global warming to understand their complexities and spur international cooperation. The goal of this study article is to delve into these challenges' many sides, illuminating their effects, causes, mitigation tactics, and adaptation techniques in Nigeria. It seeks to provide answers to the question: How do climate change and global warming explain longevity in Nigeria? This leads to the hypotheses stated as follows:

Ho1: Precipitation/rainfall does not reduce longevity in Nigeria.
Ho2: Temperature does not reduce longevity in Nigeria.
Ho3: Environment does not reduce longevity in Nigeria.
Ho4: Unemployment does not reduce longevity in Nigeria.
Ho5: Infant mortality does not reduce longevity in Nigeria.

In doing so, the paper contributes to a collective effort that seeks to ensure the viability of our planet for generations to come. This research work is divided into six sections. Following this introduction, section two provides a literature review on the topic, that is, previous works on or related to the topic. Section three provides the methodology of the study, while section four presents the pre-estimation test results and section five discusses the findings. Section six provides the conclusion with policy recommendations.

2. LITERATURE REVIEW

Conceptual Framework

Concept of Life Expectancy

A key indicator of population health is life expectancy since it measures mortality throughout a population's life. Life expectancy in a pre-modern, underdeveloped world was about 30 years. Life expectancy has risen quickly since the Age of Enlightenment, which has resulted in significant health disparities. The average life expectancy in the world has more than doubled since 1900 and is now around 70 years. The Central African Republic has the lowest life expectancy at 53 years, while Japan has a 30-year life expectancy (Roser et al., 2013). Nevertheless, there is still a significant discrepancy between and within nations. Life expectancy nevertheless offers a good indicator of average life durations.

Concept of Climate Change

The average temperature of the Earth's atmosphere, oceans, and land masses consistently rising above the ambient temperature is referred to as global climate change (Climate Change). According to some scientists, the planet's present rapid warming is being caused by an increase in greenhouse gases, or "heat-trapping gases". This is brought on by an excessive buildup of carbon dioxide (CO_2) in the atmosphere of the Earth, which serves as a blanket to trap heat and warm the globe. Burning fossil fuels, destroying forests, as well as specific agriculture and waste management techniques, are the causes of this. The mechanism through which greenhouse gases retain radiant energy (heat) that is delivered from the Sun to the Earth, warming the atmosphere, is known as the greenhouse effect (Eneji, 2017).

Causes of Climate Change

A. Greenhouse Gas Emissions

Greenhouse gases, which trap heat in the Earth's atmosphere and cause global warming, are the main causes of climate change. These gases are produced by a variety of human endeavors and have a major effect on the planet's climate system.

1. Carbon Dioxide (CO_2) from Burning Fossil Fuels: Another strong greenhouse gas is methane, which can trap heat for longer periods than CO_2 does. The digestion of animals (enteric fermentation), the management of manure, Climate Change, and Global Warming 5, and the decomposition of organic waste in landfills are some of the sources that emit it. For short-term climatic effects to be reduced, methane emissions must be addressed.
2. Methane (CH_4) from Livestock and Landfills: Another potent greenhouse gas is methane, which can trap more heat over a shorter period than CO_2 does. It is released by several processes, such as manure management, livestock digestion (enteric fermentation), Climate Change and Global Warming 5, and the breakdown of organic waste in landfills. The reduction of methane emissions is essential for reducing the effects of the climate now.
3. Nitrous Oxide (N_2O) from Agricultural Practices: Nitrous oxide (N_2O) is released into the atmosphere as a result of agricultural activities, particularly the use of synthetic fertilizers and specific land management techniques. An important greenhouse gas that weakens the ozone layer and contributes to global warming is nitrous oxide. Optimizing fertilizer use, enhancing soil management, and implementing more environmentally friendly agriculture methods are all strategies to lower N_2O emissions.

B. Deforestation and Land-Use Changes

1. Reduced Carbon Sequestration Capacity: Deforestation occurs when forests are cleared for activities like logging, agriculture, and urban development. Forests are essential for carbon sequestration because they take CO_2 from the air and store it in the soil and trees. The ability of the Earth to absorb CO_2 is reduced by deforestation, worsening the greenhouse effect.
2. Altered Regional Climates: Natural weather patterns can be disturbed by extensive deforestation and changes in land use, which can shift regional temperatures. Climate control, atmospheric circulation, and precipitation patterns are all impacted locally and globally by forests. When forests are lost, weather patterns may change, influencing where rain falls and causing droughts or floods in some areas.

C. Industrial Processes and Other Anthropogenic Activities

Cement production, mining, and other industrial processes all produce greenhouse gases and other pollutants. These emissions help to worsen air quality and contribute to global warming. Other anthropogenic influences, such as the release of fluorinated gases used in refrigeration and electronics manufacture, such as hydrofluorocarbons and perfluorocarbons, also have a significant warming potential. In conclusion, human activities that emit greenhouse gases and affect land use are the primary causes of climate change. To create successful measures to mitigate climate change and create sustainable solutions for a world that is changing quickly, it is crucial to understand these causal elements.

Theoretical Framework

Three theoretical perspectives, namely the Gaia theory, the theory of metabolism, and the life history theory served as the foundation for our research on the connection between climate change and life expectancy (longevity).

The Gaia Theory

According to James Lovelock's 1960s Gaia hypothesis of metabolism, living things interact with their surroundings and adapt to shifts in the natural world. The capacity of an organism to adapt to environmental changes is essential to its survival. A change in the composition of the atmosphere caused by excessive greenhouse gas emissions from agriculture and forest removal may have negative effects on human health. Some contend that higher carbon emissions improve longevity because they increase life expectancy in nations with high carbon dioxide emissions. Additionally, a higher air CO2 concentration might result in healthier food production, enhancing longevity and life quality.

Theory of Metabolism

According to the principle of metabolism, every living thing relies heavily on its ability to burn food per unit of body weight each day, which has an impact on how healthy an organism is. An organism's metabolic rate and body temperature are correlated, and organisms that dwell in cold environments typically have lower metabolic rates than warm-blooded species. Even though body size affects the metabolic rate, warm-blooded animals that are exposed to cooler temperatures tend to speed up their metallic process to maintain a regular body temperature. This hypothesis holds that every temperature increase, whether brought on by humans or by natural forces, tends to speed up chemical reactions. This theory's justification is that the lower the metabolic rate, the higher the life expectancy or longevity.

The Life History

Theory According to the life history theory, which was created in the 1950s, an organism's variations in the course of its life are significantly influenced by its ecological and physical surroundings. According to this idea, an unstable environment has an impact on an organism's ability to reproduce and its population dynamics. Even if the environment in this place is related to resource availability, risks, and rivals, the climate has an impact on each of the aspects. For instance, a bad climate might influence the resources available in a place, which can make it more difficult for the organisms living there to get food. Survival of the fittest results from competition for limited resources, and those who lack the strength to win a significant share may not live to their full potential.

Empirical Review

Numerous countries have conducted empirical research in response to concerns about the effects of carbon emissions and climate change on public health. According to certain studies Balan, (2016), Jerumeh et al., (2015), Ali and Ahmad, (2014), life expectancy is better in nations with low carbon emissions, indicating that carbon emission is bad for longevity. In 25 EU nations, Balan, (2016) investigated the relationship between carbon emissions and life expectancy. The study's findings indicated that, in general, CO2 emissions have a negative and significant impact on life expectancy, but that, depending on the source of the emissions, CO2 emissions from petroleum have a positive impact on life expectancy while those from natural gas and coal have a negative impact. The results are consistent with a 2007 study by Deschenes and Greenstone that found that, given current greenhouse gas emissions, the death rate in America will increase by the end of the twenty-first century.

However, some research indicates that CO2 emissions may lengthen life. They are (Monsef and Mehrjardi, 2015; Delavari et al., 2008). Monsef and Mehrjardi, (2015) found that life expectancy rises when CO2 emission rises in panel research of 136 nations. Although CO2 emission was not considerable, its positive impact on life expectancy implies that it is not hazardous to human health. This is in line with research by Delavari et al., (2008) in Iran, which found that CO2 emissions have a small but positive impact on life expectancy there. On the flip side of climate change, the impact of global warming and the rise in the average temperature of the environment on human health has been studied. According to Wuebbles and Edmonds, (1988), the earth's surface warms up more when it is exposed to the sun's direct radiation, and the temperature rise has both immediate and long-term consequences on people's health. Extreme heat and stress are exacerbated by high temperatures, which can be problematic for those who have respiratory health issues.

For instance, a study conducted in Mozambique revealed a correlation between an increase in the average environmental temperature and a rise in the frequency of stroke cases (Gomes et al., 2015). Agwu and Okhimamhe, (2009) found that an increase in the average environmental temperature caused changes in Nigerians' health patterns. Agwu and Okhimamhe, (2009) found that residents of Zumba and Augie communities in Niger and Kebbi state in the north, as well as Enugwu Nanka and Akama Amankwo Ngwo communities in Anambra and Enugu, had higher rates of asthma, hypertension, ulcer, malaria, diarrhea, diabetes, and typhoid. These findings came from a cross-section study of communities in North-Central and South-Eastern Nigeria. Similarly, to this, WHO, (2015) found that Nigeria's average temperature will rise by 4.9°C between 1990 and 2100, which will likely 1 lead to an increase in diarrhea-related diseases.

Additionally, studies by Davies et al., (2004) and Zanobetti et al., (2012) revealed that deaths in American cities always peak during periods of intense heat, particularly among the elderly and those who had diabetes, congestive heart failure, and myocardial infarction. Additionally, Hajat and Kosatky, (2010), Burges et al., (2014), Anderson and Bell, (2009) provide evidence that greater temperatures increase mortality. According to Anderson and Bell, (2009) research, American mortality increases with increasing heat intensity and duration. Medina-Ramon and Schwartz, (2007) earlier study in American cities had varied results, which was unfortunate. For example, they discovered that changes in summer temperature will raise overall mortality, but that mortality will be higher for those who get myocardial infarction and cardiac arrest in cold weather.

Many academics agree that unfavorable weather conditions and global warming may lead to an increase in health-related issues. They are (Kalkstein and Smoyer, 1993; Deschenes, 2012; Caleb, 2012; Seltenrich, 2015). Although Deschenes and Greenstone, (2007) argued that the climate is a crucial component of the planet that sustains human life, Deschenes, (2012) and Caleb, (2012) argue that climate change poses a threat to human existence due to its impact on the water and air that people breathe and drink. In terms of public health, breathing in polluted air can lead to asthma attacks and lung inflammation, as well as other health problems WHO, (2015a), Patrick and Kinney, (2008), Pope et al., (2002), while contaminated water can lead to illnesses like diarrhea (Khan et al., 2012). Huang et al., (2012) found that due to its impact on blood pressure, irregular temperature can make persons with cardiovascular issues' health conditions worse.

According to studies conducted throughout the world, an increase in the global average temperature is hazardous to human life since it increases the risk of heat-related illnesses like stroke, asthma, and injury to a growing fetus (Salau, 2016; Zivin and Shrader, 2016). Kalkstein and Valimont, (1987) conclude that more fatalities occur during periods of high heat after reviewing the research. Even while climate change does not directly create new diseases, Samet, (2010) argues that it nevertheless poses a hazard to human life since it has the potential to make asthma and hay fever sufferers' conditions worse. Moore, (2008) gives a distinct perspective on how the average environmental temperature rise affects human health. According to him, the effects of climate change and rising temperatures are not entirely harmful to humans because there are some positive aspects as well. Moore argues that it may not be accurate to state categorically that a temperature rise is bad for human health because, according to experience, more people pass away in the winter than in the summer.

This claim is consistent with Deschenes and Greenstone, (2007) claim that life will undoubtedly continue despite climate change since it will enhance the intake of nutritious foods that can prolong life. According to Chau et al., (2014) study conducted in Hong Kong, hospitalizations for ischemic heart disease occur more frequently in the winter when it's chilly outside than in the summer when it's hot. According to a 2012 study by Egondi et al., (2012) in Nairobi, Kenya, deaths are generally greater in colder climates; however, only when temperatures reach over 75% do non-communicable illness patients and children under the age of five experience an increase in mortality. Although several empirical studies have shown that greater temperatures have a detrimental impact on life expectancy, Andersen and Verner, (2009) found that temperature and precipitation had a positive but negligible impact on life expectancy both at the community and national levels of analysis.

According to the research, life expectancy grows as the global mean temperature rises. In a parallel cross-country study in Europe, Bardi and Perini, (2013) likewise found that life expectancy is rising in the countries they looked at, despite the continent's rising temperature. However, their research showed that when temperatures rise, healthy life expectancy declines. The indicator of a person's change in health condition is their healthy life expectancy. The indicator of a person's change in health condition is their healthy life expectancy. The occurrence or absence of chronic diseases and the length of a disease determine changes in people's health status. In Bolivia, Winters, (2012) found that poor people's quality of life had decreased similarly as a result of climate change and bad weather.

After reviewing pertinent literature, the current paper can contribute to our understanding of climate change and public health, particularly in Nigeria. First, public health and industrial pollution were the subjects of earlier research in Nigeria. Since Nigeria is not an industrialized nation, just a small portion of the nation's CO_2 emissions come from the industrial sector (World Bank, 2016). In 2008, the industrial sector's CO_2 emissions accounted for less than 1% of all greenhouse gas emissions. Second, the current study examined more variables that have an impact on life expectancy. Thirdly, and most importantly, the results varied, which is a caution that using the wrong determining variables and data might lead to misleading results in an empirical study.

3. METHODOLOGY

This study intends to shed light on how global warming and climate change impact life expectancy in Nigeria. The ex-post factor analysis is looking at the years 1991 through 2021. The data's source also included the World Development Indicators (WDI). The impact of climate change and global warming longevity in Nigeria was estimated using the Autoregressive Distributed Lags (ARDL) estimation method. Carbon dioxide (C02) emissions (metric tons per person) serve as a proxy for global warming and the environment, whereas temperature and rainfall do so for climate change. The addition of unemployment (UN) and the infant mortality rate as control variables was also supported by the theoretical premise that a person with a job may live longer than one without one, while a lower baby mortality rate increases longevity.

The Model

Variables considered are:
Life expectancy rate (LE)
Precipitation/rainfall (RN)
Temperature (TP)
Carbon dioxide (C02)
Infant mortality rate (IM)
Unemployment (UN)

LE= f (RN, TP, C02, IM, UN) ………………………………………………………. (1)

This can be specifically expressed in explicit econometric (linear equation) form as:

$LE = \beta 0 + \beta 1RN + \beta 2TP + \beta 3C02 + \beta 4IM + \beta 5UN + U$…………………………. (2)

Where U – stochastic or random error term (with usual properties of zero mean and non-serial correlation).

Apriori Expectation

The a priori expectations are that all the βis, δis, and φis < 0. That is, lagged values of explanatory variables in the short-run as well as estimated values of the same variables in the long-run are expected to have negative effects on IFMR. Thus, the expected signs of the coefficients of the explanatory variables are $\beta 1 < 0$, $\beta 2 < 0$, $\beta 3 < 0$, $\beta 4 < 0$, and $\beta 5 < 0$; this implies that all the explanatory variables are expected to have negative effects on the infant mortality rate. This study provides empirical evidence on how climate change and global warming explain the longevity in Nigeria.

Estimation Techniques

The relationship between the variables in our model will be examined for analysis using the autoregressive distributed lag (ARDL) technique. If any of the explanatory factors and the dependent variable are non-stationary, estimating equation 1 by the ordinary least squares (OLS) method may produce erroneous findings and inferences. To identify the features of the data, i.e., whether it is stationary and the order of integration, the Augmented Dickey-Fuller unit root test is employed to ascertain whether the variables have unit roots. Next, the Autoregressive Distributed Lag (ARDL) method created by used to determine whether or not the variables in the equation have a long-term relationship. It primarily serves to determine whether the independent variables can accurately forecast the dependent variable in the short- and long-term. Short-run equilibrium may not happen even though the regression model's variables may have a long-run equilibrium relationship.

The error correction mechanism (ECM), which is used to correct or eliminate the disparity that happens in the short-run, is used to simulate the short-run dynamic adjustment. The percentage of the disagreement between the variables that can be removed in the following period is given by the coefficient of the error correction variable. It blends short-run dynamics with long-run equilibrium relationships between the variables while simultaneously adjusting for short-term disequilibrium. This methodology is used because it provides richness, flexibility, and versatility to econometric modeling. This makes it easier to anticipate with accuracy how the variables' economic linkages will play out. This methodology is employed due to its adaptability and capacity to handle variables with various degrees of stationarity, such as I (0) and I (1), as well as to enable forecasting, mean and median lag analysis, multiplier analysis, policy analysis, and multiplier analysis.

Pre-Estimation Test Result

Descriptive Analysis

The summary statistics and correlation are labeled Tables 2 and 3 for descriptive statistics and correlation coefficient respectively. Table 2 reveals the summary statistics of all the variables used in this research irrespective of the models they are included. Before going into the main regression analysis, it is important to show the relationship between longevity proxy by life expectancy (LE) and climate change proxy by temperature (TP) and rainfall (RN), global warming (environment) proxy by carbon dioxide (C02) emissions (metric tons per capita), unemployment (UN) and infant mortality (IM) rate. Mean is the average value of the series and from Table 2, the mean for life expectancy (LE) is 47 years, 8 months, and 4 days approximately, while the mean for carbon dioxide (C02), rainfall (RN), and temperature (TP) is 0.63 metric tons per capita, 1324.41 mm, and 27.130C respectively. In addition, the mean for unemployment (UN) and infant mortality (IM) are respectively 5.50% and 110.79 per 1,000 live births.

Table 2 Summary Statistics

Variables	LE	CO2	RN	TP	UN	IM
Mean	47.61604	0.631887	1324.417	27.13000	5.499377	110.7883
Median	46.51000	0.620000	1311.700	27.13000	5.944000	119.9000
Maximum	55.44000	1.010000	1411.000	27.86000	7.900000	168.6000
Minimum	39.71000	0.330000	1272.000	26.27000	1.600000	56.68000
Std. Dev.	3.466368	0.179144	33.50071	0.393363	1.664220	26.90672
Skewness	0.030595	0.021483	0.558230	-0.346403	-0.808125	-0.014304
Kurtosis	2.610660	2.201835	2.231118	2.483249	2.754806	2.361348
Jarque-Bera	0.343019	1.410932	4.058175	1.649650	5.901517	0.902533
Probability	0.842392	0.493878	0.131455	0.438312	0.052300	0.636821
Sum	2523.650	33.49000	70194.10	1437.890	291.4670	5871.781
Sum Sq. Dev.	624.8167	1.668811	58359.47	8.046200	144.0207	37646.53
Observations	53	53	53	53	53	53

Source: Author’s Compilations using Eviews 12 Edition (2023); (Ref: Annexure)

Keynotes: LE= Life expectancy at birth, total (years), TP= Temperature TEMP= Temperature Increase (°C), RN = Precipitation/rainfall in mean annual (mm), C02= Carbon dioxide emissions (metric tons per capita), IM = Infant mortality rate, and UN = Unemployment (UN).

The median is the middle value of the series when the values are arranged in an ascending or descending order. From Table 2, the median for life expectancy (LE) is 46 years, 6 months, and 12 days approximately, while the median for carbon dioxide (C02), rainfall (RN), and temperature (TP) are 0.62 metric tons per capita, 1311.70 mm, and 27.130C respectively. In addition, the median for unemployment (UN) and infant mortality (IM) are respectively 5.94% and 119.9 per 1,000 live births. Maximum is the highest value of the series for the period under study. Table 2 indicates that the maximum value for LE is 55.44 years approximately, while the maximum values for C02, RN, and TP are 1.01 metric tons per capita, 1411mm, and 27.860C respectively. On the other hand, the minimum values for UN and IM are 7.9%, and 168.6 per 1,000 live births respectively. The minimum is the lowest value of the series for the period under study.

Table 2 indicates that the minimum value for LE is 39.71 years approximately, while the minimum values for C02, RN, and TP are 0.33 metric tons per capita, 1272 mm, and 26.270C respectively. On the other hand, the minimum values for UN and IM are 1.6%, and 56.68 per 1,000 live births respectively. Standard Deviation is a measure of spread or dispersion in the series. From Table 2 the standard deviation for LE, C02, RN, TP, UN, and IM are 3.47 years, 0.179 metric tons per capita, 33.5 mm, 0.390C, 1.66%, and 26.91 per 1,000 live births respectively. This shows that climate change proxy by rainfall (RN) has the largest spread over the period under study while environment proxy by carbon dioxide emissions by metric ton per capita (C02) has a minimal spread over time. Skewness is a measure of the probability distribution of a real-valued random variable about its mean.

A normal distribution is symmetrical at point 0. If the value is greater than zero it is positively skewed but if it is less than zero, it is negatively skewed. From Table 2, it is observed that all the variables have positive skewness. Kurtosis measures the peakness or flatness of the distribution of the series. If the kurtosis is above 3, the distribution is peaked or leptokurtic relative to the normal and if the kurtosis is less than three, the distribution is flat or platykurtic relative to normal. From Table 2, all the variables are less than 3. Therefore, they are not leptokurtic relative to normal distribution. Jarque-bera is a test statistic to test for the normal distribution of the series. From Table 2, the Jarque-bera for LE, C02, RN, TP, UN, and IM are 0.34 years, 1.41 metric tons per capita, 4.06 mm, 1.650C, 5.90%, and 0.90 per 1,000 live births respectively. The probability value of the Jarque bera statistic of all the variables was found to be more than 5% level of significance which implies acceptance of the null hypothesis which states that the residual of the variables is normally distributed with zero means and constant variance.

The Correlation Result

The correlation result is shown in (Table 3).

Table 3 Correlation\

Variables	LE	CO2	RN	TP	UN	IM
LE	1	-0.088823	-0.631492	0.743430	0.459959	-0.986112
CO2	-0.088823	1	0.002038	-0.201862	-0.202834	0.174362
RN	-0.631492	0.002038	1	-0.638286	-0.673443	0.660258
TP	0.743430	-0.201862	-0.638286	1	0.479927	-0.782770
UN	0.459959	-0.202834	-0.673443	0.479927	1	-0.530356
IM	-0.9861122	0.174362	0.660258	-0.782770	-0.530356	1

Source: Author's computation in Eviews 12 Edition (2023); (Ref: Annexure)

The correlation coefficients in Table 3 above show that the independent variable is not highly correlated with each other. This will ease the problem of serial correlation. However, it is observed that rainfall (RN) is highly and positively correlated with infant mortality (IM) while temperature (TP) is highly and negatively correlated with infant mortality (IM). In addition, rainfall (RN) is highly and negatively correlated with unemployment (UN). A high correlation between the independent variable with the dependent variable is good but between independent variables is bad (Gujarati). Nevertheless, with ARDL, the issue of serial correlation will be automatically corrected as per and therefore is expected not to distort the model during estimation.

The Graphs

Before formal pretest (unit root tests), the study plots the time series of the variables under study as it may help reveal the integrating nature of the variables life expectancy (LE), temperature (TP), rainfall (RN), carbon dioxide (C02) emissions (metric tons per capita), unemployment (UN) and infant mortality (IM) rate are examined graphically as depicted below in Figure 1 which shows clear trend spanned 1970 to 2022.

Unit Root Test

The unit root results presented in Table 4 is the augmented dickey fuller test (ADF) which was chosen because it is widely used and its output is said to be robust. The stationarity of the variables is concluded based on the outcome of both ADF at constant only or constant and trend techniques. The results show that all the variables are stationary at either level or first difference. The summary result is posted in Table 4, therefore, based on the result of this stationarity test, the adoption of the ARDL technique could be given a pass since none of the variables is stationary beyond order one.

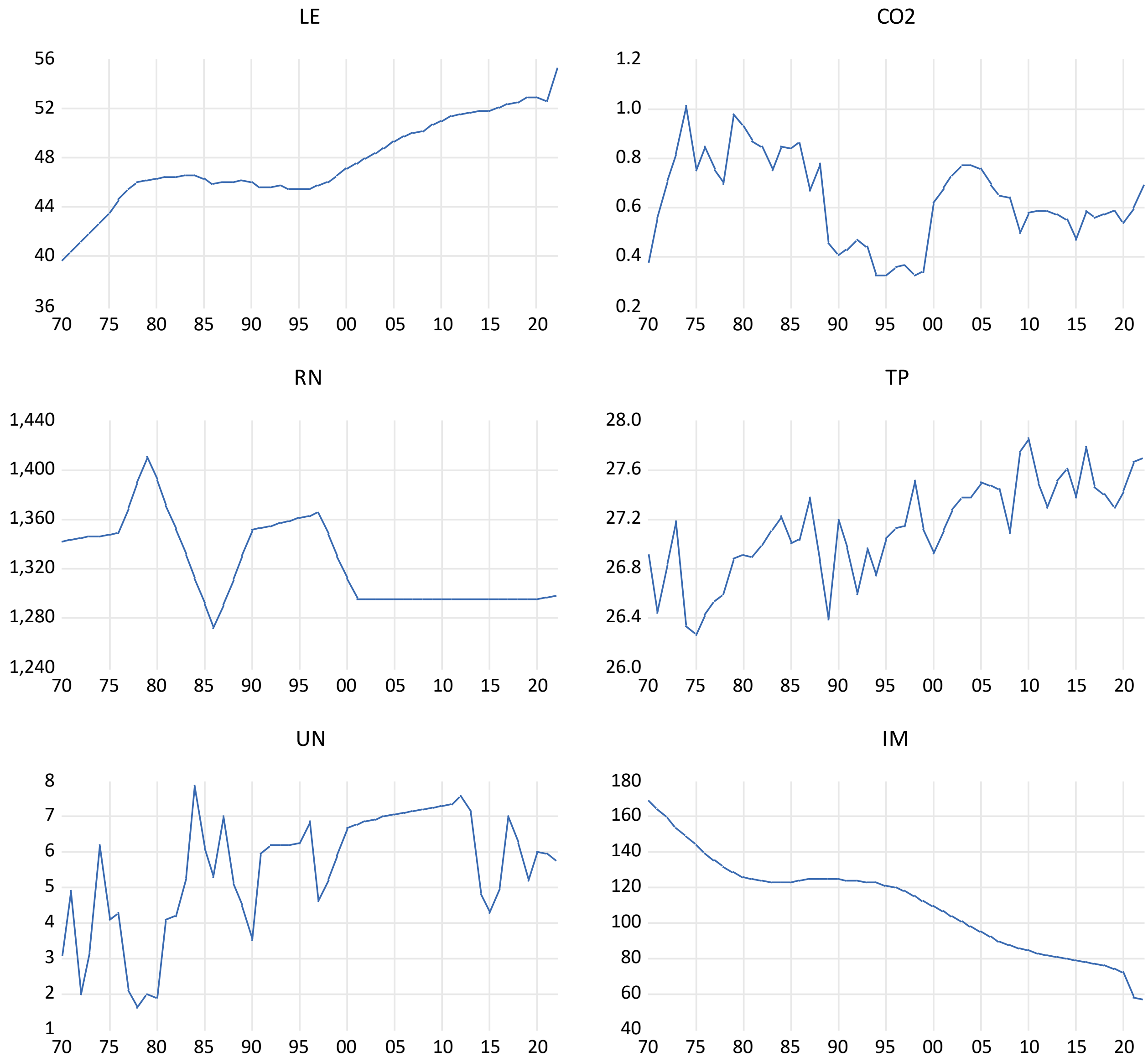

Figure 1

Source: Author's Computation in Eviews 12 (2023); (Ref: Annexure)

Table 4 Unit Root Test

Variables	ADF	Prob	5%		
LE	-3.946665	0.6156	-3.500495	I (1)	No Unit Root
CO2	-8.045198	0.0000	-3.500495	I (1)	No Unit Root
RN	-4.326619	0.0062	-3.500495	I (0)	No Unit Root
TP	-5.750950	0.0001	-3.498692	I (0)	No Unit Root
UN	-3.648991	0.0353	-3.498692	I (0)	No Unit Root
IM	-3.527902	0.9841	-3.500495	I (1)	No Unit Root

Source: Author's Computation in Eviews 12 (2023) ; (Ref: Annexure)

4. RESULTS AND DISCUSSION

Error Correction Regression (Short-Run)

Table 5, is the error correction model (ECM) (short-run) regression. The results in the short-run estimates in Table 5 are interpreted in percentages just as they appear since the variables are either in percentages, index, or logged. In the short run, all the estimated coefficients are significant at a 5% level of significance and while some are also negatively significant, others are positively significant.

Table 5 Error Correction Regression (Short-Run)

Variables	Coefficients	Standard Error	t-Statistic	Prob.
D (LNC02 (-1))	-0.216148	0.122054	1.770917	0.0435
D(LNRN)	0.142334	0.071800	1.982382	0.0356
D (LNRN (-1))	-0.111922	0.064795	-1.727316	0.0432
D (UN)	-0.050656	0.050440	-1.490003	0.0354
D (UN (-1))	-0.061180	0.070405	2.914408	0.0063
D (UN (-2))	-0.080776	0.040403	1.926105	0.0225
D (LNTP)	0.055841	0.065691	3.558709	0.0011
D (LNIM (-1))	-0.147352	0.025178	-5.852436	0.0000
D (LNIM (-2))	-0.231663	0.084335	-2.746945	0.0096
CointEq (-1)*	-0.230352	0.041841	-5.505370	0.0000

Source: Author's Computation in Eviews 12 (2023); (Ref: Annexure)

The findings show that in the short run, and a year after, global warming/environment proxy by carbon dioxide (C02) in metric tons per capita significantly reduced longevity proxy by life expectancy rate in Nigeria. In other words, a unit increase in global warming reduces longevity by 0.22% in Nigeria. Therefore, global warming is a good predictor of longevity in Nigeria. This finding is in agreement with Balan, (2016), Jerumeh et al., (2015), and Ali and Ahmad, (2014) who show that carbon dioxide (C02) hurts life expectancy (longevity). The results also show that rainfall and temperature which both proxy climate change respectively reduce and increase longevity. In other words, a unit increase in rainfall reduces longevity by 0.14% while a unit increase in temperature reduces longevity by 0.05% in the first year in Nigeria.

However, rainfall increases longevity in a year after as a unit change in precipitation reduces longevity by 0.11%. Therefore, climate change is a good predictor of longevity in Nigeria. Similarly, results show that in the short run, unemployment reduces longevity both at levels a year and two years later. Therefore, unemployment is a good predictor of longevity in Nigeria. Similarly, the infant mortality rate significantly reduces longevity at levels and a year after, indicating that this variable is also a good predictor of longevity in Nigeria. In the same way, since the coefficient of Cointeq (-1) is negative (0.23), significant (P= 0.0000), and in between -1 and 0, it ensures that the equilibrium formed is converging and stable. It means that if policymakers intervene by 1% change in the independent variables (C02, RN, TP, UN, and IM), there is a likelihood of improved longevity (increase in life expectancy).

Twenty-three (23) percent of the policy target will be achieved in one year. This means that the policy lag of this model is 4.33 years (Policy lag = 1 / (conteq (-1), that is 1/0.23= 4.329). Hence, policymakers must consider future patterns of climate change and global warming in Nigeria while devising longevity (life expectancy) policy. By so doing it will ensure the sustainable long life of the citizens in Nigeria. As pointed out above, the coefficient of the error correction variable (ECM (-1)) is, as expected, negatively signed, statistically significant at a 5 percent level and its absolute value lies between zero and unity. Consequently, it will act to correct any deviations from long-run equilibrium. However, the size of the absolute value of the error-correction coefficient shows that the speed of restoration to equilibrium in the event of any temporary displacement is too slow (23%).

Long-Run Regression

The results in the long-run estimates in Table 6 are interpreted in percentages just as they appear since the variables are either in percentages, index, or logged.

Table 6 Long-Run Estimates

Variables	Coefficients	Standard Error	t-Statistic	Prob.
LNC02	-0.111720	0.019359	-0.605408	0.0389
LNRN	-0.332208	0.343737	-0.966461	0.0406
LNTP	-0.174704	0.266553	-0.655419	0.0336

UN	-0.007057	0.004553	-1.549750	0.0305
LNIM	-0.266452	0.027549	-9.672033	0.0000

Source: Author's Computation in Eviews 12 (2023); (Ref: Annexure)

Still, in the long run, all the independent variables (C02, RN, TP, UN, and IM) significantly reduce longevity in Nigeria. Masozera et al., (2007), Miller et al., (2021), Orru et al., (2017), Wang et al., (2021), and Watts et al., (2015) who find adverse effects of climate change on longevity. The next section is the statistical test of the hypothesis.

Statistical Test of Hypotheses

This study is designed to answer how climate change and global warming composition explain the longevity opportunities in Nigeria. Thus, are hypotheses stated in null becomes. The Wald test and associated p-value were used to evaluate the five hypotheses put forth in this study. The probability value served as the basis for deciding whether to accept or reject the null hypothesis (PV). The regressor in question is implied to be statistically significant at the 5% level if the PV is less than 5% or 0.05 (i.e., PV 0.05); otherwise, it is not significant at that level.

Hypothesis One (H01)

Ho1: Precipitation/rainfall does not reduce longevity in Nigeria.

Table 7 Results of Wald Test on Precipitation/rainfall in Nigeria

Test Statistic	Value	Df	Probability
t-statistic	-0.678410	34	0.0402
F-statistic	0.460240	(1, 34)	0.0402
Chi-square	0.460240	1	0.0497

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

The Wald-test in Table 7 showed that the estimated F-value for and was determined to be -0.68 and its probability value is 0.0402. We rejected the first null hypothesis (H01) and concluded that Precipitation/rainfall reduced longevity in Nigeria between 1970 and 2022 since the probability value was less than 0.05 or 5 percent threshold of significance, which fell in the acceptance region.

Hypothesis Two (H02)

Ho2: Temperature does not reduce longevity in Nigeria.

Table 8 Results of Wald Test on Temperature in Nigeria

Test Statistic	Value	Df	Probability
t-statistic	1.448581	34	0.0156
F-statistic	2.098385	(1, 34)	0.0156
Chi-square	2.098385	1	0.0147

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

The Wald-test in Table 8 showed that the estimated F-value for TP was determined to be 2.10 and its probability value is 0.0156. We rejected the second null hypothesis (H02) and concluded that Temperature reduced longevity in Nigeria between 1970 and 2022 since the probability value was less than 0.05 or 5 percent threshold of significance, which fell in the acceptance region.

Hypothesis Two (H03)

Ho3: Environment (C02 emissions) does not reduce longevity in Nigeria.

Table 9 Results of Wald Test on Environment (C02 emissions) in Nigeria

Test Statistic	Value	Df	Probability
t-statistic	-1.476677	34	0.0490
F-statistic	2.180575	(1, 34)	0.0430
Chi-square	2.180575	1	0.0398

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

The Wald-test in Table 9 showed that the estimated F-value for C02 was determined to be 2.18 and its probability value is 0.0430. We rejected the third null hypothesis (H03) and concluded that environment (C02 emissions) did not reduce longevity in Nigeria between 1970 and 2022 since the probability value was less than 0.05 or 5 percent threshold of significance, which fell in the acceptance region.

Hypothesis Two (H04)

Ho4: Unemployment does not reduce longevity in Nigeria.

Table 10 Results of Wald Test on Unemployment in Nigeria

Test Statistic	Value	Df	Probability
t-statistic	-2.242857	34	0.0315
F-statistic	5.030409	(1, 34)	0.0315
Chi-square	5.030409	1	0.0249

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

The Wald-test in Table 10 showed that the estimated F-value for UN was determined to be 5.03 and its probability value is 0.0315. We rejected the fourth null hypothesis (H04) and concluded that unemployment reduced longevity in Nigeria between 1970 and 2022 since the probability value was less than 0.05 or 5 percent threshold of significance, which fell in the acceptance region.

Hypothesis Two (H05)

Ho5: Infant mortality does not reduce longevity in Nigeria

Table 11 Results of Wald Test on Infant Mortality in Nigeria

Test Statistic	Value	Df	Probability
t-statistic	1.310838	34	0.0198
F-statistic	1.718297	(1, 34)	0.0198
Chi-square	1.718297	1	0.0189

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

The Wald-test in Table 11 showed that the estimated F-value for IM was determined to be 1.72 and its probability value is 0.0198. We rejected the second null hypothesis (H05) and concluded that infant mortality reduces longevity in Nigeria between 1970 and 2022 self since the probability value was less than 0.05 or 5 percent threshold of significance, which fell in the acceptance region.

Model Evaluation

Table 12 also shows the ARDL bound test result, the F_PSS value is 3.680390, which is bigger than the 1%, 5%, and 10% upper bound values showing that there is cointegration among the proposed variables.

Table 12 Model Evaluation, ARDL Bound Test Result

Test Statistic	Value	K (df)
Bound F-statistic	3.680390	5
Critical Values Bound		
Significance	Lower Bound F	Upper Bound F

10%	2.08	3
5%	2.39	3.38
2.5%	2.7	3.73
1%	3.06	4.15
Evaluation Test		
F-statistic	1287.152	-
Durbin Watson (DW)	2.050152	-
R-square	0.898242	-

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

By examining the overall fit and significance of the model, the probability *F-statistic* value of 0.000000 is less than 0.05 (Table 12), by inference, it could be observed that the model is fit. There is no autocorrelation among the variables as captured by the Durbin Watson (DW) statistic of 2.050152, which is at the threshold of 2. It shows an unbiased estimate and the model could be used for policy decisions. The coefficient of determination (R-square), used to measure the goodness of fit of the estimated model (Table 12), indicates that the model is excellently fit in prediction, that is, 0.898 or 90 percent change in longevity/life expectancy (LE) was due temperature (TP), rainfall (RN), carbon dioxide (C02) emissions (metric tons per capita), unemployment (UN) and infant mortality (IM) rate collectively, while about 10 percent unaccounted variations was captured by the white noise error term such as the influence of governance, environment and so on. It showed that the independent variables have a strong significant impact on longevity/life expectancy in Nigeria.

Table 13 Post-Regression Diagnostics

Diagnostics	F-statistic	Probability
JB Normality Test	0.571514	0.7514
BG Serial Correlation LM	0.786506	0.4640
Obs*R-squared	2.342674	0.3100
BPG Heteroskedasticity Test	0.890835	0.5800
Obs*R-squared	14.10664	0.5175

Source: Author's Computation, 2023 (Eviews-12); (Ref: Annexure)

Since the post regression tests in Table 13 are insignificant at a 5% level of significance there is no issue in the model. Figure 2 is a model stability test (CUSUM of Squares) graph which confirms that the mean and variance of the model is stable to any unknown change to the model.

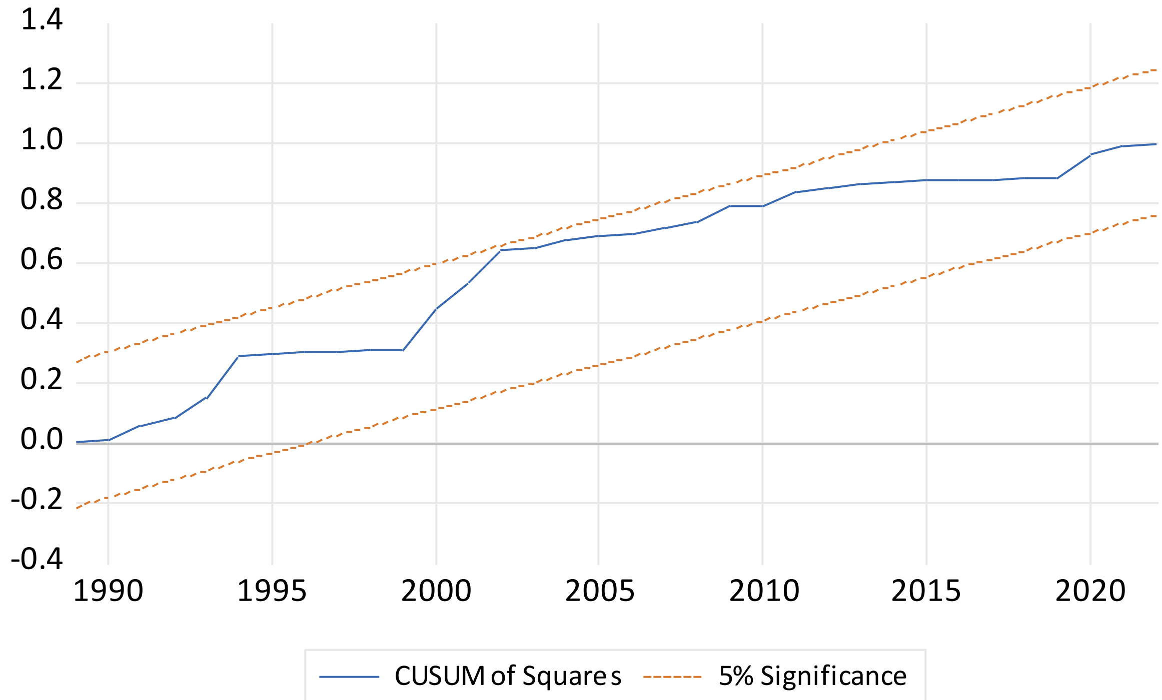

Figure 2 Model Stability Test (CUSUM of Squares)
Source: Author's Computation in Eviews 12 (2023); (Ref: Annexure)

5. CONCLUSION AND POLICY RECOMMENDATIONS

This study aims to clarify how longevity in Nigeria is explained by climate change and global warming mix. The period being considered in the ex-post factor investigation is from 1970 to 2022. Additionally, the World Development Indicators (WDI) were used as the data's source. The Autoregressive Distributed Lags (ARDL) estimation method was used to estimate the effect of climate change and global warming on longevity. The findings show that in both the short run and long run, all the independent variables proxy climate change and global warming significantly reduce longevity in Nigeria. These findings are in tandem with the results by Masozera et al., (2007), Miller et al., (2021), Orru et al., (2017), Wang et al., (2021), and Watts et al, (2015) who found adverse effects of climate change and global warming on longevity. The Wald test and associated p-value were used to evaluate the five hypotheses put forth in this study.

The probability value served as the basis for deciding whether to accept or reject the null hypothesis (PV). The regressor in question is implied to be statistically significant at the 5% level if the PV is less than 5% or 0.05 (i.e., PV< 0.05); otherwise, it is not significant at that level. The Wald test results show that all the independent variables significantly reduce longevity in Nigeria. In the same way, since the coefficient of Cointeq (-1) is negative (0.23), significant (P= 0.0000), and in between -1 and 0, it ensures that the equilibrium formed is converging and stable. It means that if policymakers intervene by 1% change in the independent variables (C02, RN, TP, UN, and IM), there is a likelihood of improved longevity (increase in life expectancy). Twenty-three (23) percent of the policy target will be achieved in one year. This nbmeans that the policy lag of this model is 4.33 years (Policy lag = 1 / (conteq (-1), that is 1/0.23= 4.329). Hence, policymakers must consider future patterns of climate change and global warming in Nigeria while devising longevity (life expectancy) policy. By so doing it will ensure the sustainable long life of the citizens in Nigeria.

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Author Contributions
I am the sole contributor to this research.

Informed consent
Not applicable.

Ethical approval
Not applicable.

Conflicts of interests
The authors declare that there are no conflicts of interests.

Funding
The study has not received any external funding.

Data and materials availability
All data associated with this study are present in the paper.

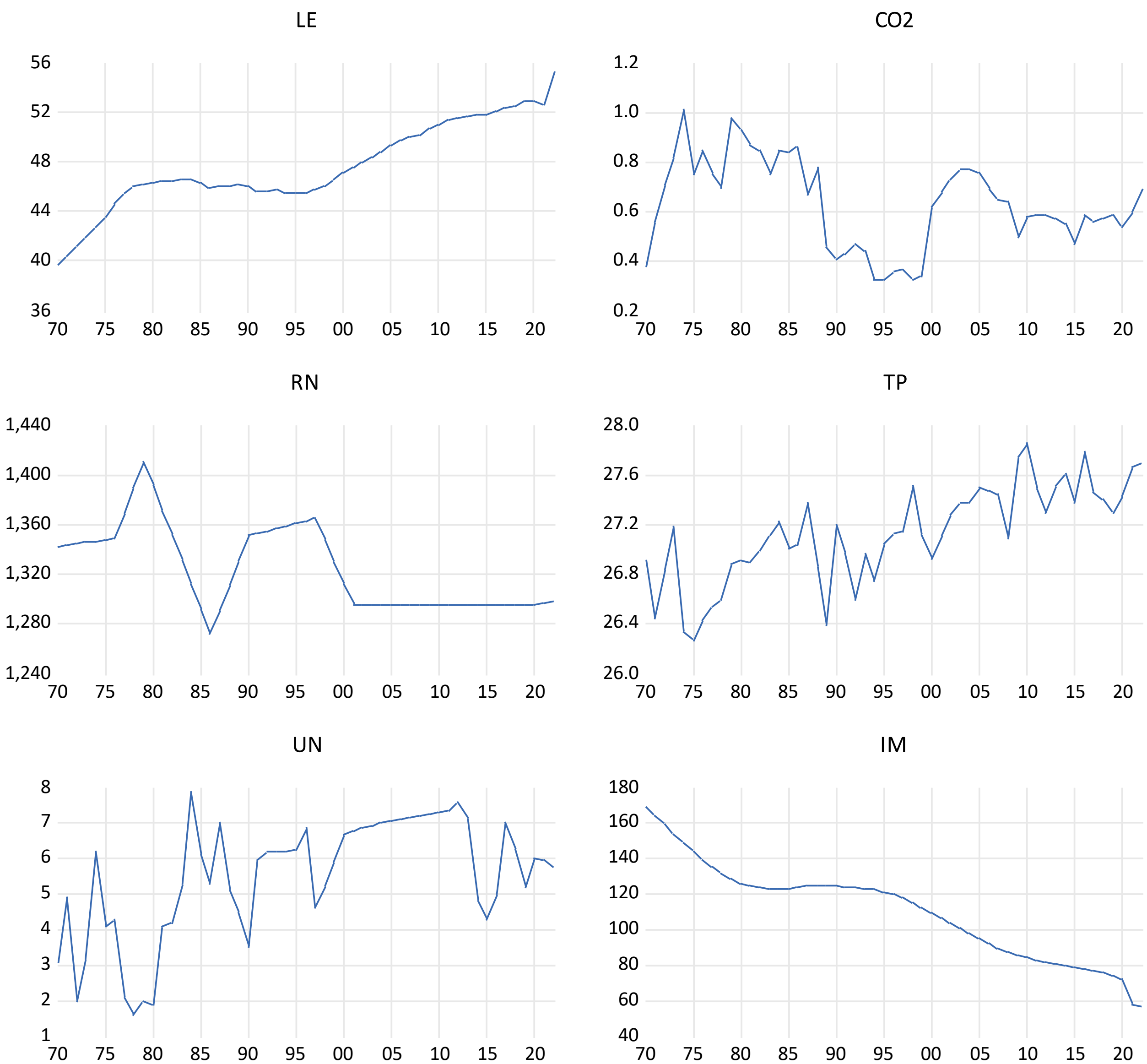
Annexure
Tony Climate Change Eviews Results

le c02 rn tp un im

	LE	CO2	RN	TP	UN	IM
Mean	47.61604	0.631887	1324.417	27.13000	5.499377	110.7883
Median	46.51000	0.620000	1311.700	27.13000	5.944000	119.9000
Maximum	55.44000	1.010000	1411.000	27.86000	7.900000	168.6000
Minimum	39.71000	0.330000	1272.000	26.27000	1.600000	56.68000
Std. Dev.	3.466368	0.179144	33.50071	0.393363	1.664220	26.90672
Skewness	0.030595	0.021483	0.558230	-0.346403	-0.808125	-0.014304
Kurtosis	2.610660	2.201835	2.231118	2.483249	2.754806	2.361348
Jarque-Bera	0.343019	1.410932	4.058175	1.649650	5.901517	0.902533
Probability	0.842392	0.493878	0.131455	0.438312	0.052300	0.636821
Sum	2523.650	33.49000	70194.10	1437.890	291.4670	5871.781
Sum Sq. Dev.	624.8167	1.668811	58359.47	8.046200	144.0207	37646.53
Observations	53	53	53	53	53	53

	LE	CO2	RN	TP	UN	IM
LE	1	-0.08882394972626095	-0.6314920588973785	0.7434302890970048	0.4599597123284809	-0.9861122309621242
CO2	-0.08882394972626095	1	0.002038937461695383	-0.2018629373129523	-0.2028346023294056	0.174362257370515

RN	-0.6314920588973785	0.002038937461695383	1	-0.638286655628674	-0.6734439544924632	0.6602587332848372
TP	0.7434302890970048	-0.2018629373129523	-0.638286655628674	1	0.4799277281677317	-0.7827707629899674
UN	0.4599597123284809	-0.2028346023294056	-0.6734439544924632	0.4799277281677317	1	-0.5303568239014167
IM	-0.9861122309621242	0.174362257370515	0.6602587332848372	-0.7827707629899674	-0.5303568239014167	1



lnle c lnc02 lnrn lntp un lnim

ARDL Error Correction Regression
Dependent Variable: D(LNLE)
Selected Model: ARDL(2, 0, 2, 0, 3, 3)
Case 2: Restricted Constant and No Trend
Date: 08/30/23 Time: 12:14
Sample: 1970 2022
Included observations: 50

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNC02(-1))	-0.216148	0.122054	1.770917	0.0435
D(LNRN)	0.142334	0.071800	1.982382	0.0356
D(LNRN(-1))	-0.111922	0.064795	-1.727316	0.0432
D(UN)	-0.050656	0.050440	-1.490003	0.0354
D(UN(-1))	-0.061180	0.070405	2.914408	0.0063
D(UN(-2))	-0.080776	0.040403	1.926105	0.0225
D(LNTP)	0.055841	0.065691	3.558709	0.0011
D(LNIM(-1))	-0.147352	0.025178	-5.852436	0.0000
D(LNIM(-2))	-0.231663	0.084335	-2.746945	0.0096
CointEq(-1)*	-0.230352	0.041841	-5.505370	0.0000

R-squared	0.922096	Mean dependent var	0.005903
Adjusted R-squared	0.904568	S.D. dependent var	0.009508
S.E. of regression	0.002937	Akaike info criterion	-8.645919
Sum squared resid	0.000345	Schwarz criterion	-8.263514
Log likelihood	226.1480	Hannan-Quinn criter.	-8.500297
Durbin-Watson stat	2.050152		

* p-value incompatible with t-Bounds distribution.

F-Bounds Test Null Hypothesis: No levels relationship

Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	3.680390	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

Dependent Variable: LNLE
Method: ARDL
Date: 08/30/23 Time: 12:14
Sample (adjusted): 1973 2022
Included observations: 50 after adjustments
Maximum dependent lags: 4 (Automatic selection)

Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LNC02 LNRN LNTP UN LNIM
Fixed regressors: C
Number of models evaluated: 12500
Selected Model: ARDL(2, 0, 2, 0, 3, 3)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNLE(-1)	0.985796	0.169645	5.810921	0.0000
LNLE(-2)	-0.216148	0.146375	-1.476677	0.1490
LNC02	-0.002700	0.003980	-0.678410	0.5021
LNRN	0.142334	0.098258	1.448581	0.1566
LNRN(-1)	-0.330781	0.147482	-2.242857	0.0315
LNRN(-2)	0.111922	0.085382	1.310838	0.1987
LNTP	-0.040243	0.062075	-0.648306	0.5211
UN	-0.000656	0.000525	-1.249861	0.2199
UN(-1)	0.000211	0.000521	0.404865	0.6881
UN(-2)	-0.000404	0.000564	-0.716569	0.4785
UN(-3)	-0.000776	0.000556	-1.396344	0.1717
LNIM	0.055841	0.017953	3.110447	0.0038
LNIM(-1)	-0.264571	0.023628	-11.19744	0.0000
LNIM(-2)	-0.084311	0.128287	-0.657203	0.5155
LNIM(-3)	0.231663	0.114635	2.020883	0.0512
C	1.866421	0.523651	3.564244	0.0011

R-squared	0.898242	Mean dependent var	3.870138
Adjusted R-squared	0.997467	S.D. dependent var	0.063293
S.E. of regression	0.003186	Akaike info criterion	-8.405919
Sum squared resid	0.000345	Schwarz criterion	-7.794072
Log likelihood	226.1480	Hannan-Quinn criter.	-8.172924
F-statistic	1287.152	Durbin-Watson stat	2.050152
Prob(F-statistic)	0.000000		

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

ARDL Long Run Form and Bounds Test
Dependent Variable: D(LNLE)
Selected Model: ARDL(2, 0, 2, 0, 3, 3)
Case 2: Restricted Constant and No Trend
Date: 08/30/23 Time: 12:15
Sample: 1970 2022
Included observations: 50

Conditional Error Correction Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.866421	0.523651	3.564244	0.0011
LNLE(-1)*	-0.230352	0.066705	-3.453288	0.0015
LNC02**	-0.002700	0.003980	-0.678410	0.5021

LNRN(-1)	-0.076525	0.067560	-1.132689	0.2653
LNTP**	-0.040243	0.062075	-0.648306	0.5211
UN(-1)	-0.001626	0.000886	-1.834376	0.0754
LNIM(-1)	-0.061378	0.022262	-2.757015	0.0093
D(LNLE(-1))	0.216148	0.146375	1.476677	0.1490
D(LNRN)	0.142334	0.098258	1.448581	0.1566
D(LNRN(-1))	-0.111922	0.085382	-1.310838	0.1987
D(UN)	-0.000656	0.000525	-1.249861	0.2199
D(UN(-1))	0.001180	0.000752	1.568508	0.1260
D(UN(-2))	0.000776	0.000556	1.396344	0.1717
D(LNIM)	0.055841	0.017953	3.110447	0.0038
D(LNIM(-1))	-0.147352	0.037841	-3.893988	0.0004
D(LNIM(-2))	-0.231663	0.114635	-2.020883	0.0512

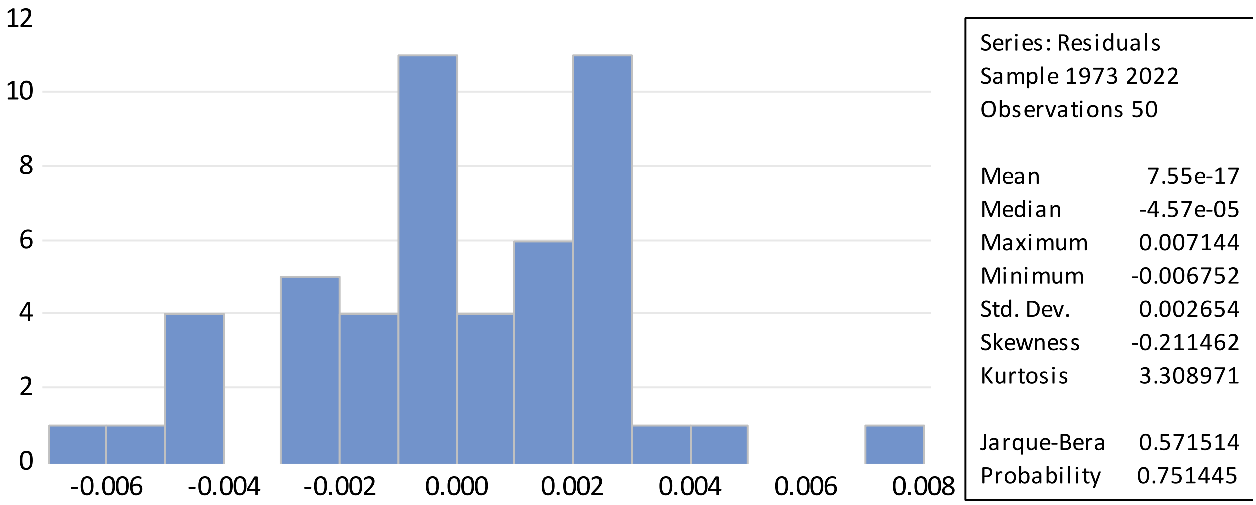
* p-value incompatible with t-Bounds distribution.
** Variable interpreted as Z = Z(-1) + D(Z).

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNC02	-0.011720	0.019359	-0.605408	0.0389
LNRN	-0.332208	0.343737	-0.966461	0.0406
LNTP	-0.174704	0.266553	-0.655419	0.0336
UN	-0.007057	0.004553	-1.549750	0.0305
LNIM	-0.266452	0.027549	-9.672033	0.0000
C	8.102483	2.589995	3.128378	0.0036

EC = LNLE - (-0.0117*LNC02 -0.3322*LNRN -0.1747*LNTP -0.0071*UN -0.2665*LNIM + 8.1025)

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	3.680390	10%	2.08	3
K	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15
			Finite Sample:	
Actual Sample Size	50		n=50	
		10%	2.259	3.264
		5%	2.67	3.781
		1%	3.593	4.981



Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.786506	Prob. F(2,32)	0.4640
Obs*R-squared	2.342674	Prob. Chi-Square(2)	0.3100

Test Equation:
Dependent Variable: RESID
Method: ARDL
Date: 08/30/23 Time: 12:20
Sample: 1973 2022
Included observations: 50
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNLE(-1)	0.300535	0.346474	0.867409	0.3922
LNLE(-2)	-0.228458	0.283088	-0.807020	0.4256
LNC02	-0.001410	0.004160	-0.338944	0.7369
LNRN	-0.037907	0.103456	-0.366411	0.7165
LNRN(-1)	0.014834	0.148978	0.099573	0.9213
LNRN(-2)	0.015637	0.088250	0.177193	0.8605
LNTP	0.001914	0.065698	0.029134	0.9769
UN	-0.000119	0.000537	-0.221710	0.8259
UN(-1)	4.84E-05	0.000560	0.086448	0.9316
UN(-2)	-0.000106	0.000585	-0.181147	0.8574
UN(-3)	0.000106	0.000568	0.185897	0.8537
LNIM	-0.000383	0.018263	-0.020955	0.9834
LNIM(-1)	-0.013292	0.030623	-0.434051	0.6672
LNIM(-2)	0.149966	0.208162	0.720431	0.4765
LNIM(-3)	-0.116971	0.174423	-0.670619	0.5073
C	-0.321891	0.653804	-0.492336	0.6258

RESID(-1)	-0.376186	0.388947	-0.967191	0.3407
RESID(-2)	-0.232417	0.217314	-1.069501	0.2928

R-squared	0.046853	Mean dependent var	7.55E-17
Adjusted R-squared	-0.459506	S.D. dependent var	0.002654
S.E. of regression	0.003206	Akaike info criterion	-8.373906
Sum squared resid	0.000329	Schwarz criterion	-7.685577
Log likelihood	227.3476	Hannan-Quinn criter.	-8.111786
F-statistic	0.092530	Durbin-Watson stat	2.045026
Prob(F-statistic)	0.999998		

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

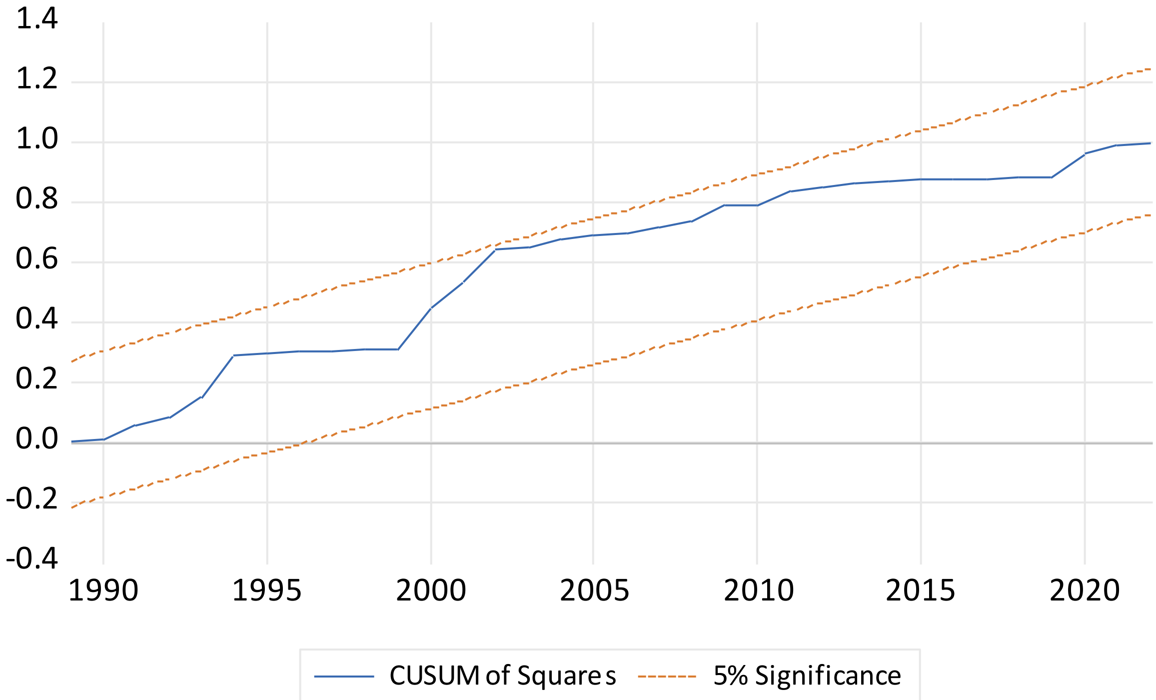
F-statistic	0.890835	Prob. F(15,34)	0.5800
Obs*R-squared	14.10664	Prob. Chi-Square(15)	0.5175
Scaled explained SS	7.530605	Prob. Chi-Square(15)	0.9412

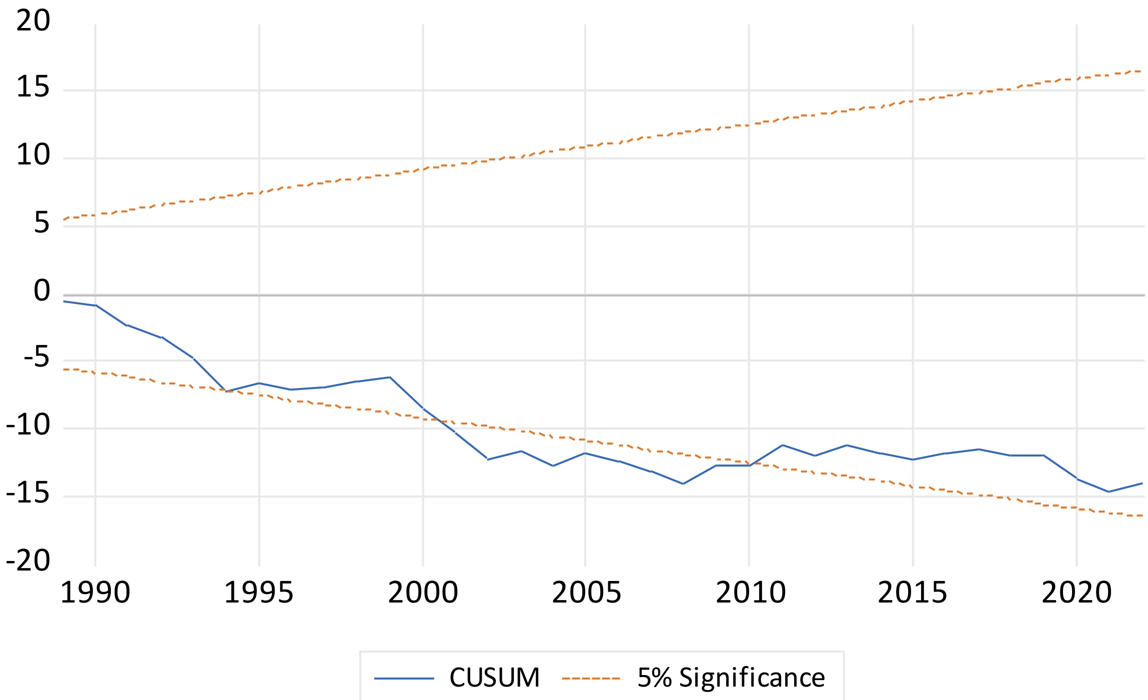
Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 08/30/23 Time: 12:21
Sample: 1973 2022
Included observations: 50

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001300	0.001771	0.734113	0.4679
LNLE(-1)	0.000287	0.000574	0.500998	0.6196
LNLE(-2)	-0.000251	0.000495	-0.506725	0.6156
LNC02	-7.63E-06	1.35E-05	-0.566646	0.5747
LNRN	-0.000106	0.000332	-0.320109	0.7508
LNRN(-1)	-1.03E-05	0.000499	-0.020556	0.9837
LNRN(-2)	7.40E-05	0.000289	0.256081	0.7994
LNTP	-0.000357	0.000210	-1.699327	0.0984
UN	1.80E-06	1.78E-06	1.011065	0.3191
UN(-1)	-3.58E-06	1.76E-06	-2.030856	0.0501
UN(-2)	3.70E-06	1.91E-06	1.940510	0.0606
UN(-3)	-6.25E-07	1.88E-06	-0.332569	0.7415
LNIM	-8.74E-06	6.07E-05	-0.143873	0.8864
LNIM(-1)	1.90E-06	7.99E-05	0.023838	0.9811
LNIM(-2)	-4.19E-05	0.000434	-0.096483	0.9237
LNIM(-3)	5.64E-05	0.000388	0.145490	0.8852

R-squared	0.282133	Mean dependent var	6.90E-06
Adjusted R-squared	-0.034573	S.D. dependent var	1.06E-05
S.E. of regression	1.08E-05	Akaike info criterion	-19.78438
Sum squared resid	3.95E-09	Schwarz criterion	-19.17254
Log likelihood	510.6096	Hannan-Quinn criter.	-19.55139
F-statistic	0.890835	Durbin-Watson stat	2.611571

Prob(F-statistic)	0.579971





Wald Tests
C(2) =0

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability

t-statistic	-1.476677	34	0.0490
F-statistic	2.180575	(1, 34)	0.0430
Chi-square	2.180575	1	0.0398

Null Hypothesis: C(2) = 0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(2)	-0.216148	0.146375

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-0.678410	34	0.0402
F-statistic	0.460240	(1, 34)	0.0402
Chi-square	0.460240	1	0.0497

Null Hypothesis: C(3) = 0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-0.002700	0.003980

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	1.448581	34	0.0156
F-statistic	2.098385	(1, 34)	0.0156
Chi-square	2.098385	1	0.0147

Null Hypothesis: C(4) = 0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.142334	0.098258

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	-2.242857	34	0.0315
F-statistic	5.030409	(1, 34)	0.0315
Chi-square	5.030409	1	0.0249

Null Hypothesis: C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.330781	0.147482

Restrictions are linear in coefficients.

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
t-statistic	1.310838	34	0.0198
F-statistic	1.718297	(1, 34)	0.0198
Chi-square	1.718297	1	0.0189

Null Hypothesis: C(6) = 0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(6)	0.111922	0.085382

Restrictions are linear in coefficients.

YEAR	LE	lnLE	CO2	lnC02	RN	lnRN	TP	lnTP	IM	lnIM	UN	GPK
1970	39.71	3.681603	0.38	-0.96758	1342	7.201916	26.91	3.292498	168.6	5.127529	3.1	22.18323
1971	40.48	3.700808	0.56	-0.57982	1343.2	7.20281	26.45	3.275256	163.8	5.098646	4.9	11.618
1972	41.27	3.720136	0.71	-0.34249	1344.3	7.203629	26.84	3.289893	159	5.068904	2	0.954898
1973	42.01	3.737908	0.82	-0.19845	1345.5	7.204521	27.19	3.302849	154	5.036953	3.2	2.854253
1974	42.79	3.756304	1.01	0.00995	1346.7	7.205412	26.34	3.271089	149	5.003946	6.2	8.34329
1975	43.66	3.776432	0.75	-0.28768	1347.8	7.206229	26.27	3.268428	144.1	4.970508	4.1	-7.77004
1976	44.72	3.800421	0.85	-0.16252	1349	7.207119	26.43	3.2745	139.5	4.938065	4.3	5.945161
1977	45.56	3.81903	0.75	-0.28768	1369.7	7.222347	26.54	3.278653	135.3	4.907495	2.1	2.885823
1978	46.02	3.829076	0.7	-0.35667	1390.3	7.237275	26.59	3.280535	131.5	4.879007	1.6	-8.58979
1979	46.22	3.833413	0.98	-0.0202	1411	7.252054	26.88	3.291383	128.6	4.856707	2	3.622444
1980	46.35	3.836221	0.93	-0.07257	1391.1	7.23785	26.91	3.292498	126.2	4.837868	1.9	1.269317
1981	46.49	3.839237	0.87	-0.13926	1371.3	7.223514	26.9	3.292126	124.5	4.824306	4.1	-15.4548

1982	46.51	3.839667	0.85	-0.16252	1351.4	7.208896	26.99	3.295466	123.5	4.816241	4.2	-3.59523
1983	46.64	3.842459	0.75	-0.28768	1331.6	7.194137	27.11	3.299903	123	4.812184	5.3	-7.42755
1984	46.55	3.840527	0.85	-0.16252	1311.7	7.179079	27.23	3.304319	123.1	4.812997	7.9	-4.46862
1985	46.32	3.835574	0.84	-0.17435	1291.9	7.163869	27.01	3.296207	123.4	4.815431	6.1	5.582075
1986	45.98	3.828207	0.86	-0.15082	1272	7.148346	27.04	3.297317	123.9	4.819475	5.3	-11.0988
1987	46.02	3.829076	0.67	-0.40048	1291.8	7.163792	27.38	3.309813	124.4	4.823502	7	-13.0645
1988	46.07	3.830162	0.78	-0.24846	1311.5	7.178927	26.86	3.290638	124.7	4.825911	5.1	4.750048
1989	46.18	3.832547	0.46	-0.77653	1331.3	7.193911	26.39	3.272985	124.8	4.826712	4.5	3.721842
1990	46.06	3.829945	0.41	-0.8916	1351	7.2086	27.2	3.303217	124.6	4.825109	3.5	9.894914
1991	45.65	3.821004	0.43	-0.84397	1353	7.21008	26.96	3.294354	124.3	4.822698	5.944	-3.1158
1992	45.67	3.821442	0.47	-0.75502	1355	7.211557	26.59	3.280535	123.9	4.819475	6.186	-2.0668
1993	45.79	3.824066	0.44	-0.82098	1357	7.213032	26.96	3.294354	123.3	4.81462	6.2	-0.4332
1994	45.51	3.817932	0.33	-1.10866	1359	7.214504	26.75	3.286534	122.5	4.808111	6.207	-1.57481
1995	45.49	3.817493	0.33	-1.10866	1361	7.215975	27.05	3.297687	121.4	4.799091	6.251	-2.75861
1996	45.57	3.81925	0.36	-1.02165	1363	7.217443	27.13	3.30064	119.9	4.786658	6.874	2.413317
1997	45.79	3.824066	0.37	-0.99425	1365	7.21891	27.14	3.301009	117.9	4.769837	4.629	0.275909
1998	46.04	3.829511	0.33	-1.10866	1347.5	7.206006	27.51	3.31455	115.4	4.748404	5.239	0.188875
1999	46.61	3.841815	0.34	-1.07881	1330	7.192934	27.12	3.300271	112.7	4.724729	5.927	-2.00238
2000	47.19	3.854182	0.62	-0.47804	1312.5	7.179689	26.92	3.29287	109.8	4.698661	6.702	2.714291
2001	47.62	3.863253	0.68	-0.38566	1295	7.166266	27.11	3.299903	106.8	4.670958	6.777	1.821728
2002	47.93	3.869742	0.73	-0.31471	1295	7.166266	27.28	3.306154	103.8	4.642466	6.853	1.200834
2003	48.44	3.880326	0.77	-0.26136	1295	7.166266	27.38	3.309813	100.8	4.613138	6.931	7.589887
2004	48.77	3.887115	0.77	-0.26136	1295	7.166266	27.38	3.309813	97.8	4.582925	7.011	30.35658
2005	49.3	3.897924	0.76	-0.27444	1295	7.166266	27.5	3.314186	95	4.553877	7.057	0.804665
2006	49.73	3.906608	0.69	-0.37106	1295	7.166266	27.47	3.313095	92.3	4.525044	7.102	5.422785
2007	50.03	3.912623	0.65	-0.43078	1295	7.166266	27.45	3.312366	89.8	4.497585	7.147	4.053715
2008	50.23	3.916612	0.64	-0.44629	1295	7.166266	27.09	3.299165	87.7	4.473922	7.192	3.492157
2009	50.71	3.926123	0.5	-0.69315	1295	7.166266	27.75	3.323236	85.9	4.453184	7.238	4.126187
2010	50.95	3.930845	0.58	-0.54473	1295	7.166266	27.86	3.327192	84.3	4.434382	7.286	4.999833
2011	51.36	3.93886	0.59	-0.52763	1295	7.166266	27.49	3.313822	83	4.418841	7.334	2.119094
2012	51.5	3.941582	0.59	-0.52763	1295	7.166266	27.3	3.306887	81.9	4.405499	7.6	1.524086
2013	51.71	3.945651	0.57	-0.56212	1295	7.166266	27.51	3.31455	81	4.394449	7.1	2.614626
2014	51.79	3.947197	0.55	-0.59784	1295	7.166266	27.61	3.318178	80.1	4.383276	4.8	3.519624
2015	51.84	3.948162	0.47	-0.75502	1295	7.166266	27.38	3.309813	79.3	4.373238	4.275	-0.02223
2016	52.04	3.952013	0.59	-0.52763	1295	7.166266	27.79	3.324676	78.3	4.360548	5.005	-4.08625
2017	52.31	3.957188	0.56	-0.57982	1295	7.166266	27.46	3.31273	77.1	4.345103	7.04	-1.8
2018	52.55	3.961765	0.57	-0.56212	1295	7.166266	27.41	3.310908	75.7	4.326778	6.25	2.2
2019	52.91	3.968592	0.59	-0.52763	1295	7.166266	27.29	3.30652	74	4.304065	5.21	1.5
2020	52.89	3.968214	0.54	-0.61619	1295	7.166266	27.43	3.311637	72.2	4.27944	6	-4
2021	52.68	3.964236	0.6	-0.51083	1297	7.167809	27.67	3.320349	57.701	4.055275	5.94	5.1
2022	55.44	4.015301	0.7	-0.35667	1298	7.16858	27.69	3.321071	56.68	4.037421	5.76	2.3

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