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The Relationship between climate change and Life Expectancy

The relationship between climate change and life expectancy and its effect on pension funds

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Dissertation

presented as partial requirement for obtaining the Master Degree Program in Statistics and Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação
Universidade Nova de Lisboa

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The Relationship between climate change and Life Expectancy and its effect on Pension Funds

By

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STATEMENT OF INTEGRITY

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DEDICATION

Dedicado a mi familia, en especial a mi madre, mi padre y mis hermanas quienes siempre me han ayudado con todo en el camino.

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ABSTRACT

Throughout the years, we have seen how populations and countries with growing economies have increased in their population. Countries able to control their consumption and resources can keep a steady and stable growth in in spite of the increase in population without issue. However, countries that lack the resources to maintain the increased population are forced to implement laws and regulations to reduce their population. We have also seen a huge rise in climate change due to various man-made mistakes, which have caused the loss of various crops and natural resources. In simple terms, we are pushing the planet to its limit, and soon enough it will break, and we will see the effects of our irreversible destruction. A study conducted jointly by Spanish, French, and Swiss researchers showed that an increase in temperature will shorten the life expectancy in Europe in the next century by three or four months, which will result in approximately 15,000 more deaths per year. This shows that the Mediterranean arc areas such as Spain, Italy, and Portugal are in the worst positions and will feel the worst of these effects. "The geographical position of the Peninsula places it in a particularly weak condition. The impact on mortality will be greater and it will begin to be noticed earlier than in the rest of the continent" (Serra, et al, 2018). The relevance of this paper is that it demonstrates the relationship between climate change and life expectancy in a more statistical manner and its effects on the economy, specifically pension funds. This finding shows that if there are no climate change policies established, it will not only cause lives to be lost but also affect the economic playing field owing to the lack of this important factor in life expectancy models.

KEYWORDS

Climate Change; Life expectancy; Pension Funds.

Sustainable Development Goals (SGD):

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LIST OF ABBREVIATIONS AND ACRONYMS

CC .... Climate Change

MRA ....Multivariate Regression Analysis

EPA ....Enviromental Protection Agency

IMF ....International Monetary Fund

NASA...National Aeronautics and Space Administration

FCCC..Framework Convention on Climate Change

IPPC..Intergovermenral Panel on Climate Change

OECD ....Organization for Economic Cooperation & Development

WEF..World Economic Forum

ECM..Error Correlarion Models

SPSS...Statistics Package for Social Science

NOAA ....National Oceanic and Atmospheric Administration

FWHO ....World Health Organization

CO2...Carbon Dioxide

CH4...Methane

GHGs...Greenhouse Gas

GDP...Gross Domestic Product

HI...Heart Illnesses

IM...Infant mortality

HC...Precentage of the population covered by Health Care

M...Methane

GT..Global Temperature

R...Respiratory Illnesses

1. Introduction

In recent decades, the impacts of climate change (CC) have become increasingly evident, posing significant challenges to global societies and economies (Bosello et al., 2006). Beyond its direct environmental consequences, CC has been linked to various effects on human health and well-being. One such area of concern is the relationship between CC and human life expectancy, a phenomenon that has garnered considerable attention in scientific and health circles. Understanding this relationship is vital because any change in climate conditions can affect human life, making it a matter of great importance (Singh & Dhiman, 2012).

As the world grapples with the consequences of a changing climate, the significance of this correlation becomes increasingly relevant. In today's context, it is crucial to comprehend the implications of CC on life expectancy for several reasons. First, the observed impacts of CC are accelerating, with more frequent and severe extreme weather events, increasing temperatures, shifting disease patterns, extinction of animals and species, among other things. These changes directly threaten human health and well-being, making it essential to gauge their potential effects on life expectancy (Hess et al., 2008).

This effect can be seen in various aspects of society, which will be discussed in more detail in Section 4. We observed that with the aging global population, retirement income schemes and financial systems are under strain. Understanding the relationship between CC and life expectancy could become a necessity. Changes in life expectancy can have profound implications for the socioeconomic landscape, such as in retirement planning, pension funds, and health-care systems. With the global population hitting the 8 billion mark, as individuals live longer, there is a need to ensure that financial systems are resilient enough to support extended retirement periods while addressing the potential health challenges brought about by a changing climate (Heller, 2005).

The objective of this thesis was to investigate the complex relationship between CC and life expectancy, starting at age 0, and discuss how it can affect the world in the economic sector. For this, we focused on how this relationship influences pension funds.

Pension funds are critical financial vehicles, providing long-term income security for individuals during their retirement years (Davis & Hu, 2004). However, the changing dynamics brought about by CC poses new challenges to the sustainability and viability of these funds; these links will be primarily conceptual.

With a quantitative approach centered on multiple regression analysis (MRA), this research was aimed at achieving the following objectives:

1. To assess the statistical relationship: The analysis sought to determine the statistical relationship between CC indicators and life expectancy. By employing MRA, we aimed to estimate the coefficients of the independent variables (CC indicators) to understand their significance and impact on life expectancy.

2. To identify the impacts of CC indicators: By conducting research and analysis, we aimed to identify the specific CC indicators with the most substantial influence on life expectancy. This objective will contribute to a more nuanced understanding of the key drivers of lower life expectancy that are associated with CC, helping policymakers and stakeholders prioritize interventions and mitigation strategies. The same will be done with life expectancy to determine where it is most affected.

3. To explore potential interactions and nonlinear relationships: The thesis seeks to go beyond linear associations and investigate potential interactions and nonlinear relationships between CC indicators and life expectancy. Understanding complex dynamics and potential synergies or amplifications among different CC factors can provide deeper insights into the mechanisms through which CC impacts life expectancy. This objective will contribute to a more comprehensive understanding of the intricate relationship between CC and lower life expectancy.

Overall, the objectives of this thesis were to provide quantitative evidence of the association between CC and lower life expectancy, identify significant CC indicators, explore interactions and nonlinear relationships, inform policy and decision-making, and enhance CC adaptation strategies. Through the achievement of these objectives, this research will contribute to the existing knowledge base, facilitate proactive measures, and ensure the long-term financial security of individuals in the context of CC and its impact on pension funds.

The study objectives will be achieved by analyzing the following scenarios: CC exacerbates various health risks, including heat-related illnesses, vector-borne diseases, respiratory disorders, and many others, all of which contribute to shorter life spans. The interplay between CC and health is multifaceted, involving complex environmental, social, and economic factors (Pizzulli et al., 2021, P.86). As individuals face a higher risk of premature mortality due to CC, pension fund managers must adapt to an altered landscape of retirement planning (Watts et al., 2021).

This study will examine the mechanisms through which CC affects life expectancy and subsequently discuss the potential consequences for the economic sector. By analyzing existing literature, statistical data, and expert opinions, we aimed to identify the key drivers of this correlation, assess the financial implications for the economic sector, or more specifically, pension funds, and propose strategies to mitigate risks and enhance resilience.

The significance of this research lies in its potential to inform policymakers, financial institutions, and pension fund managers about the long-term implications of CC on retirement planning. Understanding the relationship between CC and lower life expectancy is essential for developing proactive measures to safeguard pension funds and ensure their sustainability in an era of rapid environmental change (Catalano et al., 2020).

Studying the correlation between life expectancy and CC, along with its effects on the economic sector, holds significant relevance in addressing the challenges posed by our ever-changing climate. Understanding the impact of CC on life expectancy is crucial, as it directly affects individuals' financial planning and retirement security (Diffenbaugh & Burke, 2019). As CC impacts environmental conditions and contributes to the spread of diseases and extreme weather events, it can impact human health and potentially lead to lower life expectancies. This could have profound implications for pension funds. With decreased life expectancies, individuals have less time to accumulate sufficient assets for retirement, potentially affecting the sustainability of pension funds. Moreover, the influence of CC on investment strategies and risk management of pension funds is critical to ensuring the long-term financial stability of retirees. By comprehensively investigating the correlation between life expectancy and CC and its effects on pension funds, we aimed in this research to provide insights that can help policymakers, financial institutions, and pension fund managers. This understanding can help shape effective adaptation strategies, sustainable investment approaches, and regulatory frameworks that secure the retirement savings of individuals, given the challenges of CC (Alvarez et al., 2021).

This thesis used a multivariate regression analysis as the primary quantitative methodology to examine the correlation between CC and lower life expectancy and its effect on pension funds. The MRA allowed for the examination of multiple independent variables (CC indicators) simultaneously in relation to a dependent variable (life expectancy), enabling the identification and quantification of their individual and collective impacts (Obianyo et al., 2020).

The research gathered relevant data on CC indicators such as temperature variations, carbon dioxide (CO_2), and methane (CH_4), along with corresponding data on life expectancy, where heart illness and respiratory conditions will be used as variables, with life expectancy as a base. By employing a multivariate regression analysis, we aimed to assess the statistical relationship between these CC indicators and life expectancy, while controlling for other potential confounding variables.

The multivariate regression analysis involved estimating the coefficients of the independent variables to determine their significance and impact on life expectancy (Anthony & Ramesh, 1992, p.2-3). In addition, the analysis examined potential interactions and nonlinear relationships to capture any complex dynamics between CC and life expectancy.

By employing this methodology, the thesis aimed to provide quantitative evidence of the association between CC and lower life expectancy while quantifying the magnitude of the effects on the economic area (pension funds). The findings from the multivariate regression analysis will help elucidate the specific contributions of different CC indicators to changes in life expectancy, facilitating a better understanding of the potential mechanisms at play.

This paper includes the following chapters: Introduction, Literature Review, Methodology, Results, and Conclusions. In the first chapter, a literature review was presented that provides context, motivation, and justification for the importance of the study. In the following chapter, studies similar to the present study are cited. Subsequently, the Methodologies chapter will present a clear explanation of the methods that will be employed to reach relevant conclusions for the scientific community. The Results chapter presents the maps and values obtained through the methodologies utilized. Finally, the Conclusions chapter explains the obtained results and addresses the questions posed, while acknowledging the limitations of the present study.

2. LITERATURE REVIEW

CC poses many threats to the health and well-being of all, impacting various aspects of our lives. According to the Environmental Protection Agency (EPA) (2023), CC affects not only the food we eat but also the air we breathe, the water we use, and the economy. This can have significant implications for human health, alter the frequency and intensity of extreme weather events, and contribute to the spread of pests and diseases that affect individuals' well-being and longevity and quality of life (EPA, 2023)

In addition to the direct health consequences, longevity risk can also have indirect effects on various sectors; in this case, we will delve into its effects on pension funds. The International Monetary Fund (IMF) highlights the correlation between life expectancy and pension fund investment strategies, emphasizing that a decline in life expectancy may lead to the adoption of riskier investment approaches for pension funds. As the IMF (2017) explains, a shorter life expectancy means that individuals have less time to accumulate assets, prompting pension fund managers to seek higher returns by taking on more investment risk. However, this approach comes with greater vulnerabilities, as it amplifies the potential for larger losses if the investments underperform.

Considering these interconnected factors, it becomes evident that understanding the correlation between CC and lower life expectancy and its effect on the economic sector is of paramount importance. By comprehending the multifaceted impacts of CC on human health and well-being, policymakers, financial institutions, and pension fund managers can make informed decisions to safeguard retirement savings. This thesis was aimed at contributing to this understanding by examining the relationship between CC and lower life expectancy, shedding light on the urgent need for comprehensive adaptation strategies and policies to protect individuals' retirement savings in an increasingly uncertain future (Krogstrup & Oman, 2019; Lefevre et al., 2022).

Many other factors impact life expectancy, such as various diseases, patient characteristics, geography, and social economic factors (Correll et al., 2022, P. 67-75). However, CC is one factor that has not been taken into consideration at the appropriate level, especially in groups such as the "Global Warming Skeptics Organization" who do not believe that CC and global warming exist. This thesis establishes information on why CC affects not only our health but also our economy, particularly pension funds (Bilas et al., 2014 P.1-9).

2.1 CLIMATE CHANGE

CC has been an increasingly pressing issue in recent years, with scientists warning of its potentially devastating effects on the planet if left unchecked. This section will summarize the causes, impacts, and potential solutions to CC and how they impact human longevity. First, it will examine the various causes of CC, from human activities to natural phenomena. Second, it will examine the impact of CC on both human and natural environments, from rising sea levels to altered weather patterns. Finally, it will discuss possible solutions to the causes of CC that are multifaceted and deeply intertwined (Bellard et al., 2012 P. 365-377).

First, it is important to establish a basic difference between weather and climate. Weather refers to the specific conditions of the atmosphere at a particular place and time. This can be measured in terms of various variables, including wind speed and direction, and air temperature (NASA, 2017). Weather can change from hour to hour, day to day, and season to season. This is different from climate: "In short, climate is the description of the long-term pattern of weather in a particular area. Some scientists define climate as the average weather for a particular region and time period, usually taken over 30-years. It's really an average pattern of weather for a particular region" (Reddy, 2008 P.47). In more basic terms, weather changes from day to day. It is occurs in the then and now, while climate is a broader view and does not change in such a quick pace; rather, it takes hundreds, thousands, and even millions of years to change, or at least that is how it is supposed to be.

In 1824, Joseph Fourier calculated that a planet with the size of the Earth and our distance from the Sun should be colder. He created a theory that something in the atmosphere must act like a blanket. In 1856, Eunice Foote discovered that carbon dioxide and water vapor in the Earth's atmosphere trap escaping infrared radiation, causing the excess heat that Fourier established (Mason, 2020).

After the discovery by Foote, "In 1938, Guy Callendar connected carbon dioxide increases in the Earth's atmosphere to global warming. In 1941, Milutin Milankovic linked the ice age to the Earth's orbital characteristics. Gilbert Plass formulated the Carbon Dioxide Theory of Climate Change in 1956" (NASA, 2022).

The Framework Convention on Climate Change (FCCC) is more focused on international policy, and the Intergovernmental Panel on Climate Change (IPCC), focused on scientific assessments in support of the FCCC, does not have the same definition of CC. These two groups differ politically and perhaps even scientifically. This lack of coherence has contributed to the current international stalemate on climate policy, as it is not clear how CC should be defined. This is important because it shows that even though we are attempting to make strides as a society to improve upon these subjects, we still have long ways to go, especially if we cannot decide on a clear definition for CC. To be clear on the definition that this work used as a base, let it note that CC is defined by the United Nations as “long-term shifts in temperatures and weather patterns. These shifts may be natural, such as through variations in the solar cycle” (University of Bath, 2023).

This study investigated not only the climate but also its changes, as these impact the Earth directly and therefore affect us. For example, increasing global temperatures are expected to melt the polar ice caps. In turn, we should see elevated sea levels and more rain, and other local climate conditions could begin to vary. This could affect the climate of various areas, causing changes that alter forests, crop yields, and water supplies. As we predicted, this could also affect human health, animals, and many types of ecosystems. Deserts may expand into existing rangelands, and features of some of our National Parks and National Forests may be permanently altered (Ahmed et al., 2022).

Man has impacted the rapid acceleration of CC. Many people who do not believe in CC like to point out that before we had the beautiful green mountains or the great seas and oceans, we had an ice age, and when the ice melted, they take this fact as a way to “prove” that man has had no effect on the climate because the planet has always been heating up and nothing should be done with respect to CC, as it is going to occur regardless. The industrial sector, which uses more energy than any other end-use sector, currently consumes approximately 37% of the world's total delivered energy (Abdelaziz et al., 2011 P. 150-168).

According to a risk analysis study conducted in 1994, human activities are the primary cause of the current climate crisis. The study found that the most significant contributor to CC is the burning of fossil fuels, which release greenhouse gases (GHGs) into the atmosphere, trapping heat and causing the temperature of the planet to increase (Bostrom et al., 1994 p. 959-970). Other human activities such as deforestation and industrial agriculture have also been found to contribute to CC by releasing additional GHGs and reducing the amount of carbon dioxide absorbed by plants and trees. In addition, the risk analysis study found that natural phenomena such as changes in the Earth's orbit and volcanic eruptions can also affect the climate. However, the study concluded that the primary cause of CC is human activity. Therefore, it is essential that we take steps to reduce our GHG emissions and limit our impact on the environment to mitigate the effects of CC (Tomlinson, 2022).

CC is a global phenomenon that has a major impact on human and natural environments. Hoegh-Guldberg and Bruno (2010) conducted a study to assess this impact by examining the effects of CC on coral reefs, a critical ecosystem for humans and nature. Their research found that increasing temperatures, ocean acidity, and other changes due to CC are causing coral reefs to experience bleaching, disease, and death. This has a ripple effect that impacts other species such as fish, which rely on coral reefs for habitat and food. Furthermore, human communities are also suffering because of the loss of coral reefs. The reefs are essential for coastal protection, fisheries, and tourism, which means that their loss will have a negative economic effect on many communities. Ultimately, CC has a devastating impact on human and natural environments, and urgent action must be taken to mitigate these effects.

CC is one of the most pressing issues of our time, and it is essential that we take immediate action to mitigate its effects (Seddon et al., 2021). On the technological side, other researchers (Maroto-Valer, 2010) have suggested the use of technologies such as carbon capture, energy efficiency, and green energy. Carbon capture is a process that involves capturing carbon dioxide emissions and storing them in underground reservoirs. Energy efficiency involves the use of renewable energy sources such as solar and wind power, and green energy involves the development of new technologies that can replace fossil fuels. While these solutions may be challenging to implement, they are essential for addressing the climate crisis. We must act now and make sure that we are part of the solution to this pressing issue (Mohammad et al., 2020).

CC exacerbates mortality and illnesses associated with extreme weather events such as heatwaves, flooding, and wildfires (Ebi & Meehl, 2007). The number of daily deaths attributed to the selected causes (cardiovascular disease, hypertension, diabetes, stroke, chronic lower respiratory disease, pneumonia, and kidney disease) coded and classified according to the 10th Revision of the International Classification of Diseases was analyzed. The results of the study of Méndez-Lázaro et al. (2016) showed a significant increase in the effect of high temperatures on mortality during the summers of 2012 and 2013 in Puerto Rico.

The relationship between extreme temperatures and mortality among persons aged 45–64 years was examined. The daily mortality from January 1986 to December 1997 in Madrid was analyzed according to sex and cause (García-Herrera et al., 2005).

In 2015, an agreement was made by the United Nations Climate Change Conference, COP 21 in Paris, stating that it is important to lower GHG emissions by 40–70% before 2050. This is a grand global challenge, as approximately 80% of today's total energy supply comes from fossil fuels, which accounts for most GHG emissions. The International Agency for Renewable Energy is attempting a share of renewable energy beyond 30% by 2030, which is in line with the ambitions of COP 21. In their paper, Hansena et al. (2017) showed that “at present wind and solar power shows early signs of logistic growth despite high learning rates and energy return on energy invested particularly within the photovoltaics section. Extrapolation of the logistic time development for sun and wind combined suggests a saturation of about 1.6 TW around 2030.” This is important to note because population growth is increasing along with consumption rates. With this, we should see an impact not only on quality of life but also life expectancy.

2.2 LIFE EXPECTANCY

Recently, the world population has reached the 8 billion mark. This new quantity of people opens the door to a new ocean of questions such as "What is going to happen to the workforce when all of these new citizens grow to maturity?" and "What will happen to our pension plans and so on?" However, to learn or at least start to prepare for these scenarios, we must first know what is the life expectancy for upcoming generations (United Nations, 2023).

As defined by Our World is Data in 2023, "Life expectancy is the key metric for assessing population health. Broader than the narrow metric of the infant and child mortality, which focus solely at mortality at a young age, life expectancy at birth captures the mortality along the entire life course. It tells us the average age of death in a population."

Life expectancy is a statistical measure that reflects the average number of years a person is expected to live based on current mortality rates. It is an important indicator of the overall health and well-being of a population and is widely used to compare the health statuses of different countries, regions, and demographic groups in terms of overall health. The calculation of life expectancy involves the estimation of the number of years of life remaining to a person at a given age based on mortality rates for that age and sex, and summing these estimates for each age (Marshall et al., 2019).

The calculation of life expectancy involves the use of data from period or cohort life tables, which are statistical tables that provide information on mortality rates for different age groups or cohorts. In period life tables, all information/data used are based on historical data. Cohort life tables involve stochastic mortality projections using statistical learning, machine learning, deep learning, or ensemble methods (for a detailed review of life expectancy measurement and modeling, see, e.g., Ashofteh et al., 2022; Ayuso et al., 2021, 2022; Bravo, 2021, 2022; Bravo & Ayuso, 2020, 2021; Bravo et al., 2021a, 2021b). These tables are based on the number of deaths that have occurred in each population over a certain period and are used to estimate the number of years of life remaining for people at different ages, considering the mortality rates for that age and sex. The results are then summed to obtain an estimate of the average number of years of life remaining for a person at a particular age, which is used to calculate the overall life expectancy for that population (Office of National Statistics, 2023).

Many other factors are important in the calculation of life expectancy, one of which is the age distribution of a population, which refers to the distribution of people across different age groups. The age distribution of a population can have a significant impact on the overall life expectancy, as different age groups may have different levels of exposure to risk factors that can affect health and mortality such as lifestyle factors, access to health care, and environmental factors, which will be the focus of this thesis (Chi, 1988, p. 26-34). In this thesis, the two main variables that affect life expectancy are heat-related illnesses and respiratory deaths.

Heat-related illnesses: Increasing temperatures increase the risk of heat-related conditions such as heat exhaustion and heatstroke. Vulnerable populations, including the elderly and individuals with preexisting health conditions, are especially susceptible (Takakura et al., 2017). Figure 2.1, which was adopted from the EPA, shows the direct impacts from this.

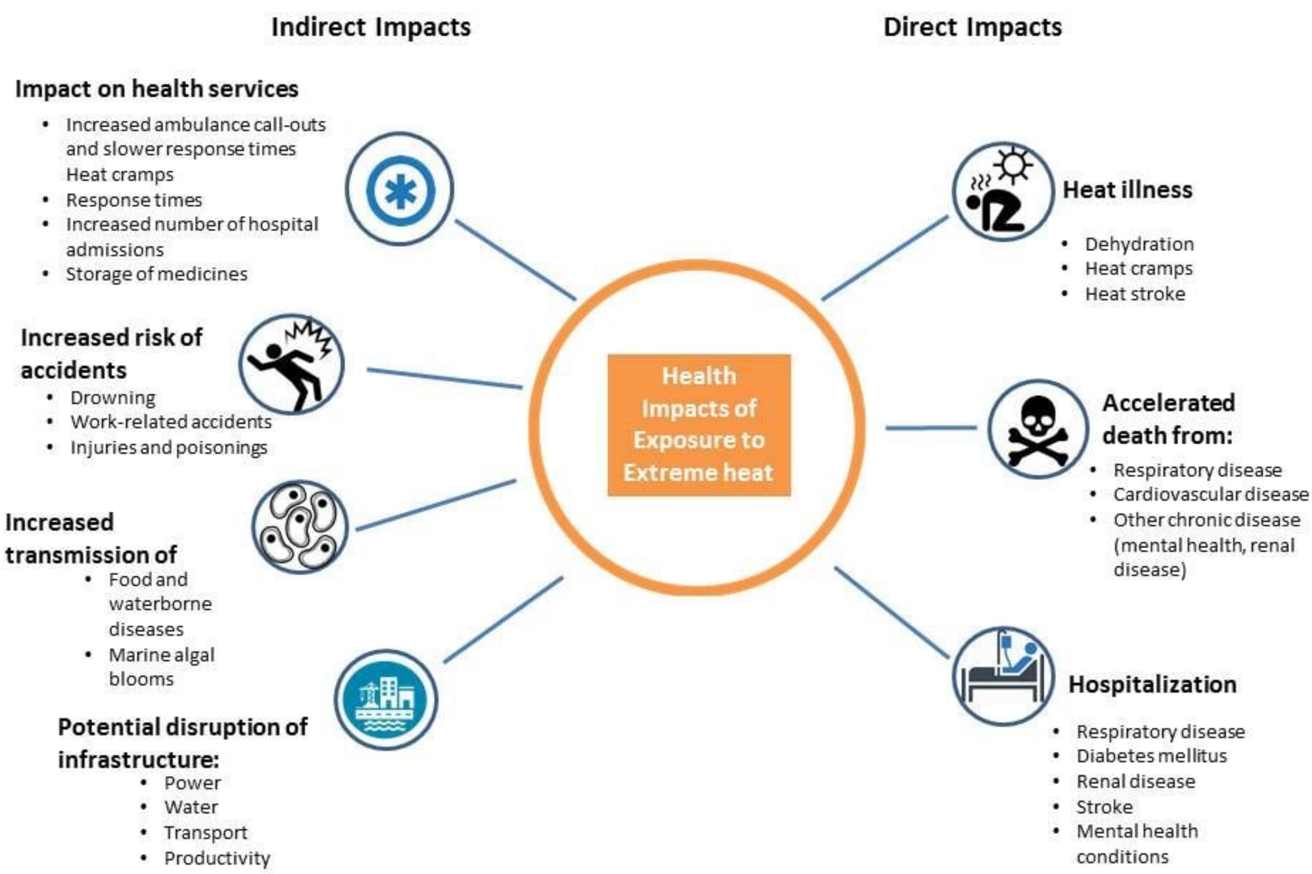

Figure 2.1 Heat impact (World Health Organization, 2018)

Respiratory conditions: Climate change contributes to air pollution, which can worsen respiratory health. Increased levels of pollutants and longer pollen seasons can exacerbate conditions like asthma and allergies. The data for respiratory conditions were taken from Our world data. (Bruzzese & Matura, 2017, p. 644-652)

In addition to these factors, life expectancy can also be influenced by other variables such as the level of development of a country, the availability of health-care services, and the levels of education and awareness of the population. These factors can have a significant impact on the overall health and well-being of a population and can play a role in determining the life expectancy of people in different countries, regions, and demographic groups (Raghupathi & Raghupathi, 2020).

Therefore, understanding life expectancy is crucial in assessing population health, especially as the world's population continues to grow (Raghupathi & Raghupathi, 2020). The calculation of life expectancy involves the use of statistical data from life tables, which take into account mortality rates for different age groups. Other important factors such as the age distribution of a population, lifestyle factors, access to health care, environmental factors, and the levels of development and education of a country can also influence life expectancy. By taking these factors into account, policymakers and health-care professionals can better understand the health-care needs of a population and develop strategies to improve health outcomes and increase life expectancy. We performed a deeper examination of how the environmental factors that are affecting our world today impact not only the life expectancy of a population but also the economic sector, more specifically pension funds.

2.3 Pension Funds

Pension funds can be defined as investment funds specifically designed to provide retirement income to individuals. These funds are created by employers or governments and are usually managed by financial institutions such as banks or investment companies. They play a critical role in providing financial security to retirees and are an essential part of retirement planning (Logue & Rader, 1998).

According to a report by the World Bank, pension funds are one of the main pillars of the retirement income system; they provide long-term savings and investment options for individuals. These funds are funded through a combination of contributions from employees, employers, and, in some cases, the government (Stewart, 2022). The amount of money that is contributed to a pension fund is based on a percentage of the employee's salary, with employers typically matching a portion of the employee's contributions. Over time, these contributions accumulate and are invested in a variety of assets such as stocks, bonds, and real estate (Fabozzi, 2022).

One main benefit of pension funds is that they allow individuals to save for retirement over a long period, which could very well be decades. The longer an individual contributes to a pension fund, the more money they will have saved for retirement. Moreover, pension funds are typically designed to provide a regular stream of income in retirement, which can help retirees maintain a certain standard of living. They are not necessarily the same amount as when they worked, but they are a percentage of the said income (Bajtelsmit & VanDerhei, 1995, p. 25- 38).

Pension funds are usually calculated on the basis of a defined contribution or benefit plan. In a defined contribution plan, the amount of money contributed to the pension fund is defined, but the retirement benefit is not guaranteed. Instead, the retirement benefit is based on the performance of the investments made by the fund. In a defined benefit plan, the retirement benefit is guaranteed, typically based on the employee's salary and years of service (Bodie et al., 1988).

According to a report by the Organization for Economic Cooperation and Development (OECD), most pension funds worldwide are defined contribution plans. In these plans, the responsibility for retirement income is shifted from employers to employees, as employees are responsible for making investment decisions and managing their own retirement savings (Tapia, 2008).

The importance of pension funds cannot be overstated, as they provide a critical source of income for retirees; without them, they could only depend on their savings. In many countries, the social security system is not sufficient to provide for all the needs of retirees, and pension funds are necessary to supplement these benefits (Babalos & Stavroyiannis, 2020). According to a report by the IMF, pension funds can help reduce poverty among the elderly and contribute to economic growth by providing a stable source of long-term financing for investments.

However, pension fund managers also face many challenges. One of them is ensuring that the retirement benefits are sufficient to provide for retirees. Ensuring this requires careful management of the funds and regular monitoring of the performance of the investments. In addition, pension fund managers must navigate a complex regulatory environment, with different countries and regions having different rules and regulations governing pension funds (Bodie et al., 1988).

Other challenges include viewing pension funds as an issue of longevity risk, or the risk that retirees will live longer than expected and require more retirement income than anticipated. According to a report by the World Economic Forum, pension fund managers must take into account the increasing life expectancy of the population and adjust their investment strategies accordingly. With this, you might believe that if people lived shorter than expected, it would be more beneficial; however, it is not that simple. A lower life expectancy can have significant effects on pension funds, particularly those that rely on defined benefit plans (World Economic Forum, 2017).

According to a report by the Organisation for Economic Co-operation and Development (OECD), a lower life expectancy can lead to reduced liabilities for defined benefit plans, as retirees will receive benefits for a shorter period (Alvarez, et al. 2021, p.363-375). This means that the pension fund must accumulate fewer assets to provide the same level of benefits, as it does not have to support retirees for as many years. A lower life expectancy may result in a higher concentration of retirees in a particular age range, which can increase the risk of benefit payments exceeding the assets available in the plan.

A study by the Society of Actuaries found that a one-year increase in life expectancy could increase pension liabilities by as much as 4% (Society of Actuaries, 2005). This highlights the importance of managing longevity risk and considering potential changes in life expectancy when in the process of creating and designing pension plans.

A lower life expectancy can also lead to changes in the investment strategies for pension funds. The IMF states that a decline in life expectancy can lead to pension fund managers taking on more investment risk, as they have less time to accumulate assets (IMF, 2017). This approach also carries greater risks, as it may result in larger losses if the investments do not perform as expected.

In their article "Implications of CC for life insurers and pension schemes," Keziah Baskerville-Muscutt and Richard Marshall stated that "climate effects—those due directly to changes in the trends in the climate drivers themselves, (rather than their economic impacts and their implications for food security and infectious disease incidence)—are small, though potentially borderline-material for deferred pensioner mortality. The changes take place very slowly, and the increase in mortality risk due to the marginal change in each driver is also only slight, so the survival of a given cohort of lives only diverges noticeably at very long durations" (Baskerville-Muscutt and Marshall, 2021). This concurs with the hypothesis that CC could cause a negative effect not only on life expectancy but also on proxy pension funds.

Overall, while a lower life expectancy can reduce the funding requirements for defined benefit pension plans, it can also create significant challenges in managing the risks associated with providing all retirement benefits. Pension fund managers must carefully consider all the potential impacts of changes in life expectancy when designing their investment and funding strategies (Auerbach et al., 2017).

In summary, pension funds are an essential part of retirement planning and provide a critical source of income for retirees. These funds are funded through a combination of contributions from employees, employers, and, in some cases, the government, and are typically invested in various assets such as stocks, bonds, and real estate. They are calculated on the basis of a defined contribution or benefit plan and are designed to provide a regular stream of income in retirement. While pension fund managers face many challenges such as ensuring sufficient retirement benefits and managing longevity risks, they play a critical role in providing financial security to retirees and contributing to economic growth (Blake et al., 2014).

On the basis of the previous research, a hypothesis was formulated that a significant negative correlation exists between CC and life expectancy, with an increase in CC leading to a decrease in life expectancy. This thesis attempts to prove this using a multiple regression analysis to show the relationship between CC and lower life expectancy, as stated earlier, unlike other works that used regressions and error correction models (Amuka et al., 2018).

The novel contribution of this thesis is the exploration of the relationship between CC and life expectancy, delving into the context of its impact on pension funds. Previous research has studied the effects of CC on various aspects of society and the environment (Dietzet al., 2020. P.135-158). There is limited understanding of how it may influence life expectancy and, in turn, have financial repercussions on pension funds.

By investigating the potential correlation between CC and reduced life expectancy, this thesis sheds light on the overlooked possible consequences that such changes could have on pension funds. If the research confirms a significant relationship, it will provide valuable insights for policymakers, pension fund managers, and stakeholders to adapt their strategies to cope with the challenges posed by a changing climate.

3. METHODOLOGY

The methodology employed in this study was aimed at investigating the relationship between CC and life expectancy. This objective was achieved using a quantitative approach that utilizes multivariable regression analysis (MRA). The MRA was performed using the Statistical Package for the Social Sciences (SPSS). Its estimation method will be squares due to its value in minimizing the squared discrepancies between observed data. This section provides an overview of the methodology, highlighting the rationale behind the chosen approach and outlining the key steps involved in the analysis. SPSS was used owing to its strong regression analysis features, especially when making connections between related factors, and usefulness in determining the connection or lack thereof between variables (Geertman, 2017).

The first step in the methodology involves the collection of relevant data pertaining to CC indicators. After the research, it was decided that the best possible indicators (Rosenblatt & Schmitz, 2016) are temperature anomalies (Hansen et al., 2006) and CO_2 (Zhang et al., 2012) and methane emissions (Schulze et al., 2009), according to reliable sources such as the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA). Life expectancy data for different regions or countries were sourced from reputable databases such as the WHO or national statistical agencies and Our World Data.

The next step involved the careful selection of variables for the regression analysis. CC indicators such as temperature anomalies and increased CO_2 and methane levels. Life expectancy variables included heat-induced and respiratory illnesses. The dependent variable was used as a proxy for overall population health. The control variables used were socioeconomic factors, which in this case were GPD, infant mortality, and the percentage of the society covered by any type of health-care system. These factors were chosen, as they were believed to be good control variables (Khalatbari-Soltani et al., 2020).

Multiple Regression Analysis: This analysis was conducted to examine the relationship between CC and life expectancy. The analyses allowed for the simultaneous assessment of multiple independent variables while controlling for confounding factors. The regression model was used to estimate the coefficients of the independent variables, indicating the strengths and directions of their influence on life expectancy (Montgomery et al., 2021).

Finally, one can interpret the obtained regression results to gain insights into the correlation between CC and lower life expectancy. Later, how this could influence pension fund performance and why it should be taken as a consideration will be explained.

In summary, the methodology employed in this study used a multivariable regression analysis to examine the correlation between CC and lower life expectancy. We will discuss why it should be taken into consideration with pension funds. By collecting and analyzing relevant data, employing rigorous statistical techniques, and addressing potential limitations, this methodology can provide valuable insights into the complex relationship between CC, life expectancy, and pension fund performance.

3.1 Analytical Method

MRA is a widely recognized and robust statistical method that allows researchers to examine the relationship between multiple independent variables and a dependent variable. In the context of studying the correlation between CC and lower life expectancy, utilizing MRA offers several advantages and is considered the optimal approach (Crawley, 2005). This approach has been described in other climate papers and journals, such as "Climate change and deepening of the North Sea fish assemblage: a biotic indicator of warming seas" (Dulvy et al., 2008).

First, MRA enables the exploration of the joint effects of multiple independent variables on the dependent variable. In the case of CC and lower life expectancy, numerous factors are at play, including temperature anomalies, extreme weather events, air pollution, and socioeconomic conditions. By incorporating all relevant variables into the regression model, we could assess their individual contributions while controlling for potential confounding effects (Madhumathi et al., 2022).

Moreover, MRA allowed for the quantification of the strengths and directions of the relationships between the independent and dependent variables. Through the estimation of regression coefficients, we can determine the magnitude of the impact of CC indicators on life expectancy. These coefficients provide valuable insights into the extent to which changes in climate variables influence changes in life expectancy, thereby establishing a quantitative measure of the correlation (Nathans et al., 2012). Furthermore, MRA provides a statistical framework for hypothesis testing and assessing the significance of relationships. By calculating *t* or F tests, we can evaluate whether the observed relationships between CC and lower life expectancy are statistically significant. This helps to determine whether the relationships are likely to be genuine or simply due to chance (Mishra et al., 2019; Petersen et al., 2021).

Another advantage of multiple regression is its ability to account for potential confounding variables. This helps to ensure that the observed correlation between CC and lower life expectancy is not solely attributed to these confounding variables (McNamee, 2005). This is the point where the model was created between CC and life expectancy. Any missing values were managed using SPSS (Bennett, 2001, p. 464-469). Other values might have been left out because of their possible inflation due to the COVID-19 pandemic.

The SPSS regression analysis tool, accessible through the Data Analysis add-in, was employed to estimate the regression coefficients. The regression model was specified, including the selection of the independent and dependent variables, and any control variables if applicable. Its formula is as follows[1]:

$$Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \sum_{j=1}^{k} \varphi_j Z_j + e_i, \quad (1)$$

where Y_i is the dependent variable life expectancy at birth, representing the expected lifespan; X_i are CC explanatory variables (e.g., Global Temperature, Methane, CO_2, Heart Illness, and Respiratory Illness) that may potentially influence life expectancy, with β_i $(i = 1, \dots n)$ as the corresponding coefficient estimates and β_0 as the intercept term; Z_j are the control variables, with φ_j $(j = 1, \dots k)$ the corresponding parameter estimates; and e_i represents the error term, accounting for any unexplained variation in life expectancy.

In terms of the controls, health conditions and other socioeconomic factors should be taken into consideration; therefore, the percentage of people with access to health care were included as a measure of health status, as they reflect the prevalence and effectiveness of health-care systems, while GDP and infant mortality were considered essential indicators of socioeconomic status. By incorporating these control variables, we aimed to control for potential confounding effects and isolate the specific contribution of other independent variables to life expectancy, thereby providing a more robust understanding of the relationships at play in our analysis. These data were taken from sources such as the macro trends and Statista.

[1] For more details, see, for example, Tranmer and Elliot (2008).

3.2 DATA

The first data sets that were obtained were those for CC. After reading various documents from sources such as NASA, NOAA, and the WHO, it was decided that the three main variables in CC that would be taken into consideration were CO_2 levels, global temperature, and methane levels; all three data sets were obtained worldwide. This is due to the fact that they have a more direct and quantitative impact not only on the planet but also on ecosystems and biodiversity (Prakash, 2021).

All the data dated back to 1992, as for a scientific article to be of good quality, the data must be at least 25 years old; therefore, therefore another 5 years were added, making the data collection period 31 years; this is also because a climate cycle is 30 years (Lean and Smyth, 2010, p. 1858-1864).

The data from the life expectancy portion were focused on heart illness and respiratory conditions in the United States. Even though the idea of a cross country would be interesting, it presents a set of challenges such as the fact that "the data for many countries in the cross-country data sets are very unreliable. They are obtained by interpolation and extrapolation of data from the same country and from related countries" (Maddala and Wu, 1999, p.631-652). Therefore, we decided to use one country with good reliable records and a diverse climate (Meek, 2019).

Consequently, the decision to focus on one country in this portion is due to the fact that a country with high medical standards, good economic growth, and no real limitations has less likelihood of human medical error or deaths caused by lack of resources and CC data.

When gathering the information for the data set, it was clear that there would have to be various variables taken into consideration; these variables were entered under the umbrella of CC. These data sets included factors that could be and have been historically measured, and would influence the entire world. Therefore, factors such as rainfall and humidity were discarded, as well as natural disasters. The three main variables were CO_2 level, global temperature, and increased methane level.

According to NASA, "Carbon dioxide (CO_2) is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels (such as coal, oil, and natural gas), from wildfires, and from natural processes like volcanic eruptions" (NASA, 2023). This means that our planet naturally produces this gas, but humans have significantly increased the volume in which this is emitted, as seen in the graph below in Figures 3.1 and 3.2 taken from the NASA website.

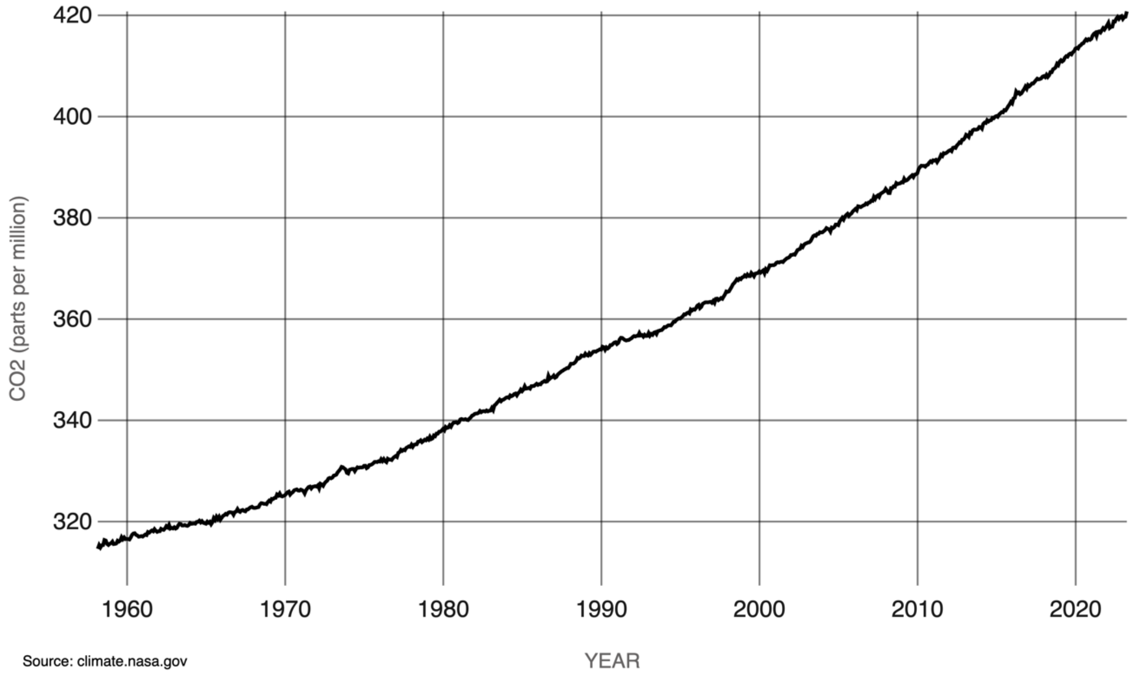

Figure 3.1 – CO2 growth 1960- Present(NASA, 2023)

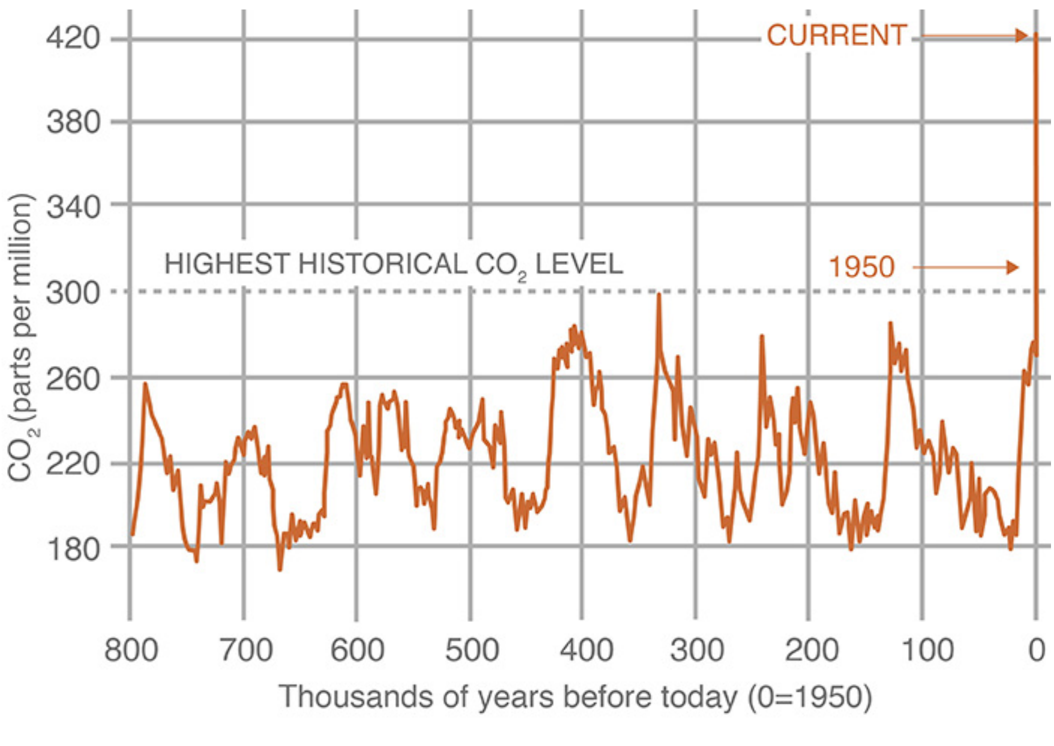

Figure3.2 – CO2 growth (NASA, 2020)

Figure 3.2 shows that in the 18th century, marked as the beginning of industrial times, human activities increased atmospheric CO_2 by 50%. This shows that the amount of CO_2 is now approximately 150% of its value in 1750. This growth is much larger than what naturally occurred at the end of the last ice age, around 20,000 years ago. The CO2 data were obtained from NOAA data sets, as these were found to be the most complete.

The following data were taken from the information on global temperature. This has a direct relationship with CO_2: “The amount of future warming Earth will experience depends on how much carbon dioxide and other GHGs we emit in coming decades. Today, our activities—burning fossil fuels and clearing forests—add about 11 billion metric tons of carbon (equivalent to a little over 40 billion metric tons of carbon dioxide) to the atmosphere each year” (Lindsey & Dahlman, 2020).

Data were also obtained from reputable sources such as NOAA and NASA, which provide comprehensive and reliable data on climate indicators, including temperature anomalies and long-term trends. Figures 3.3 and 3.4 show increases in global temperature, but for obtaining the data set, the most complete source was the Our World in Data, an open-access platform that offers a wide range of socioeconomic and health-related data from various reputable sources. The combination of temperature data from NOAA and NASA, along with the data set from Our World in Data, provides a robust foundation of information for the global temperature variable. Figure 3.3 shows that the trend of global temperatures since 1880 shows a steady increase in the planet's average temperature, particularly from the onset of the Industrial Revolution in 1950. This increase has been associated with the growth in GHG emissions, which have contributed to global warming and significant changes in worldwide climate patterns.

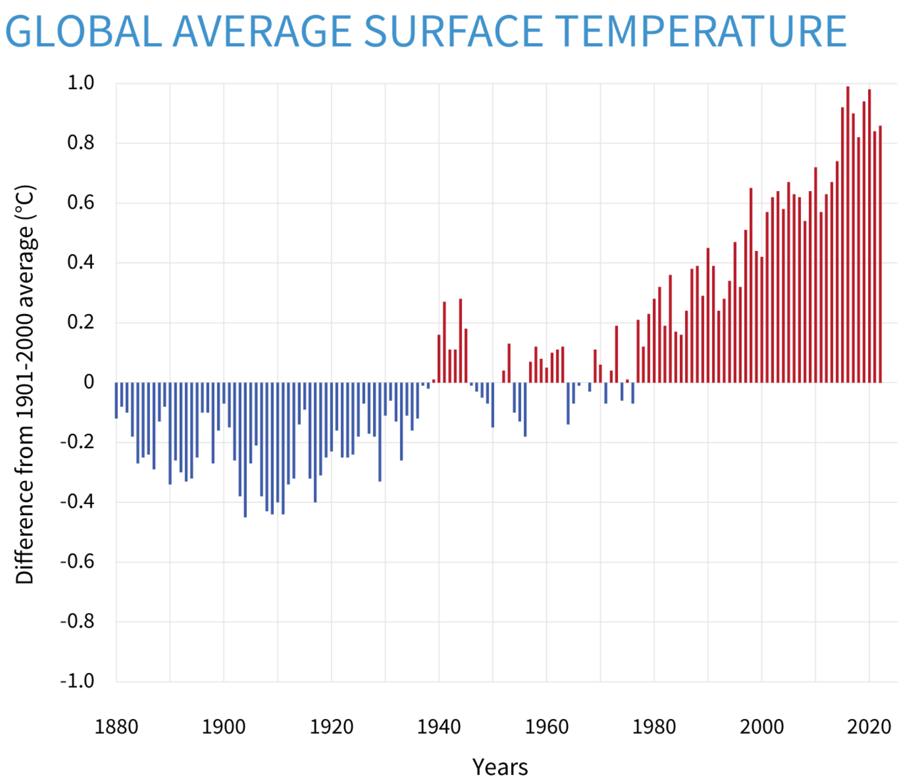

Figure3.3 – Global temperature (NOAA, 2022)

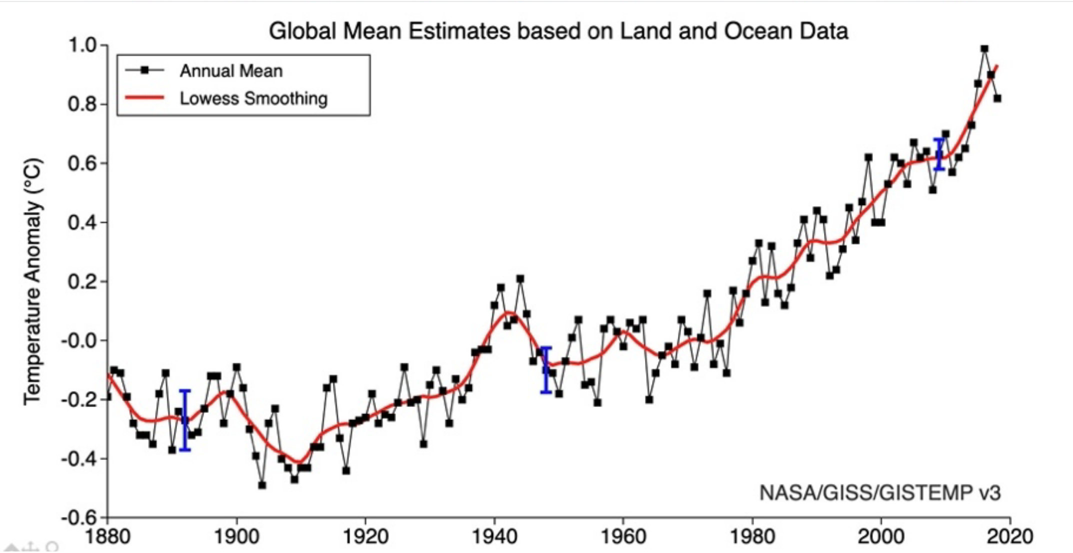

Figure3.4 – Global temperature (NASA, 2020)

Temperature and CO_2 level were the clearest indicators in terms of effect on the planet and their possible correlations with lower life expectancy, but given that CC has many variables, after a multiple regression analysis, it was decided that a third variable should be added, methane level. According to the United Nations environmental programs, "Methane is the primary contributor to the formation of ground-level ozone, a hazardous air pollutant and GHG, exposure to which causes 1 million premature deaths every year. Methane is also a powerful GHG. Over a 20-year period, it is 80 times more potent at warming than carbon dioxide" (United Nations, 2023).

Owing to these factors, methane was also taken into consideration as a variable, and while studying its effects and data, many images such as Figure 3.5 clearly show increases in methane levels throughout the years. With this information considered, methane data were collected from the same database where global temperature data were collected. All data sets from Our World Data were those for the year 1992 to 2022.

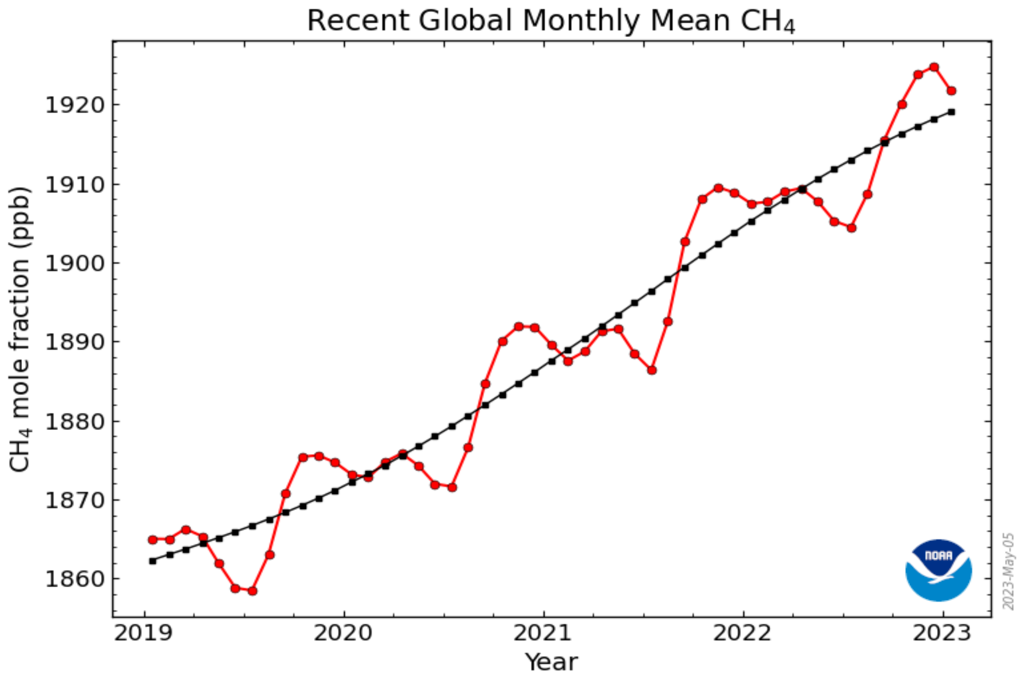

Figure3.5 – Metane Montly Mean (NOAA, 2023)

To examine the effect of CC on life expectancy, one step is determine its effect on human health. Thereby, we will find a correlation between CC and certain diseases that could decrease the mortality rate. There will be an added focus on how CC affects certain illnesses such as heart-related and respiratory illnesses (Pizzulli et al., 2021, p.86).

While conducting the MRA, other factors such as vector-borne diseases, infectious diseases, and mental health were found to potentially impact life expectancy (Baskerville-Muscutt & Marshall, 2021). These variables were not included in the regression model as independent variables owing to the understanding that they are often influenced by various complex interactions, including local health-care systems, socioeconomic conditions, and cultural factors. On the other hand, they were also chosen owing to their benefit from being more globally applicable and having a direct and measurable relationship with lower life expectancy on a global scale. By focusing on these variables, the analysis provided a better understanding of the correlation between CC and lower life expectancy.

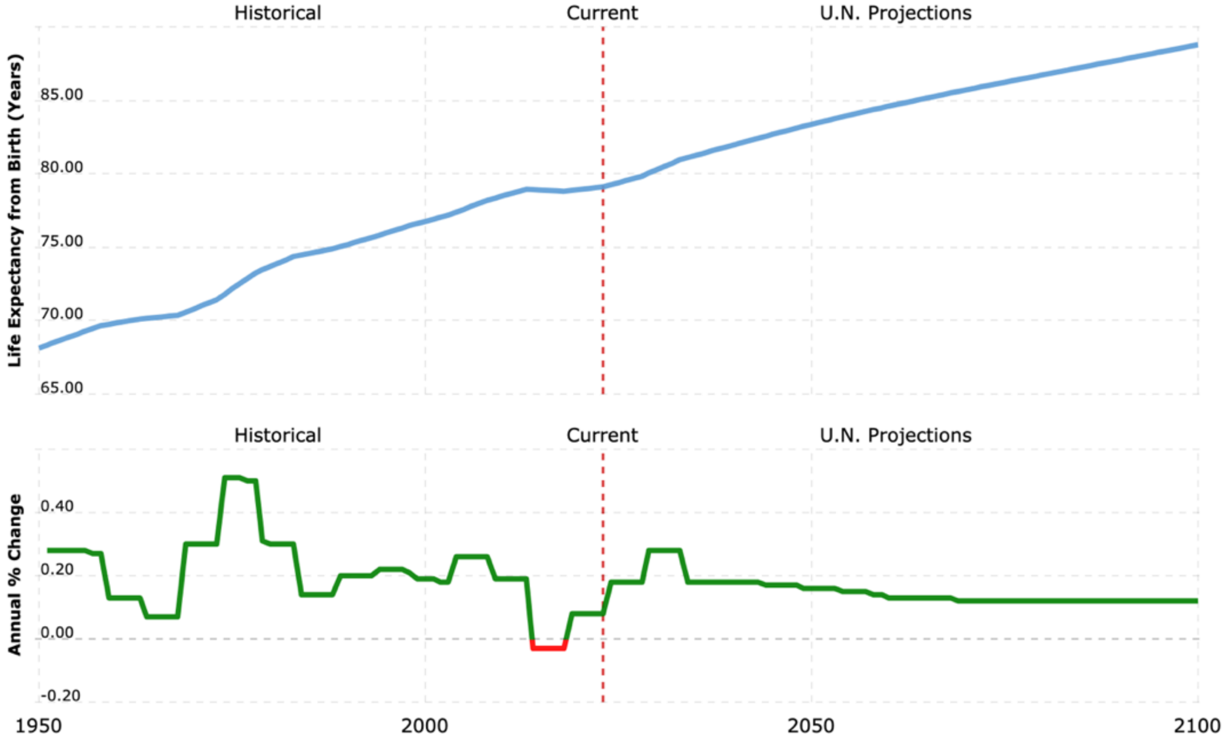

Figure3.6- ‘U.S. Life Expectancy 1950-2102, (Macro Trends, 2023)

In addition, the data of normal mortality for life expectancy were used as baseline. These data provide essential insights into the relationship between CC and lower life expectancy. They helped establish correlations, assess impacts, evaluate interventions, and inform policy decisions, contributing to a comprehensive understanding of this complex issue. This data set was taken from macro trends. Figure 3.6 shows various charts of life expectancy.

4. RESULTS AND DISCUSSION

Figures 4.1–4.2 present the results from the SPSS multiple regression analysis. A correlation is evident between the two data sets of the variables CC and life expectancy. It must be emphasized that only data for 30 years represented because this was the norm on how data should collected in the field of CC. The data set analyzed using SPSS revealed a compelling correlation between the increasing CC variables, specifically CO_2 emissions, temperatures, and methane levels, and a notable decrease in life expectancy (Brambor et al., 2006, p.63-82).

Not all control variables were useful, as some were stagnant and thus canceled by SPPS. The analysis results highlight a strong relationship between these specific factors and their impact on human health. The data indicate that higher CO_2 emissions, increasing temperatures, and increased methane concentrations significantly reduced the life expectancy rates when we used variables such as respiratory illness and heart disease to measure life expectancy. These results provide compelling evidence for the detrimental effects of these CC variables on human well-being. It is crucial to address and mitigate the alarming consequences of CO_2 emissions, temperature increases, and methane level increases to protect and improve life expectancy for future generations. The SPSS analysis results underscore the urgent need for comprehensive measures to combat CC and ensure a healthier and more sustainable future.

Table 4.1: Descriptive Statistics

	Mean	ST. Deviation	N
LE	77.71	1.27	31
GT	0.77	0.425	31
M	6	5.046	31
Co2	385.42	19.042	31
HI	57.52	3.957	31
R	36.9	2.119	31
IM	6.84	0.898	31
HC	86.955	3.0123	31
GDP	4.81	0.402	31

Table 4.2: Parameter Estimates

	Unstandarized coeffieicnets		Standard Coefficients		
Model	B	Std. Error	Beta	T	sig
(constant)	67.599	5.142		13.146	0
GT	-0.254	0.243	-0.085	-1.046	0.307
M	-0.015	0.19	-0.058	-0.757	0.457
Co2	0.32	0.15	0.475	2.174	0.041
HI	-0.085	0.28	-0.266	-3.094	0.005
R	0.6	0.76	0.1	0.791	0.438
IM	-0.399	0.198	-0.282	-2.019	0.056
HC	0.39	0.052	0.92	0.749	0.462
GDP	0.49	0.36	0.16	0.136	0.893

Table 4.3: Correlation and Covariances

Model									
Correlations		GDP	M	HI	HC	GT	R	IM	CO2
	GDP	1	-0.045	-0.084	-0.059	-0.013	-0.551	0.517	0.179
	M	-0.045	1	-0.222	0.204	-0.254	0.483	-0.029	-0.491
	HI	-0.084	-0.222	1	-0.706	0.068	-0.049	0.028	0.646
	HC	-0.059	0.204	-0.706	1	0.101	0.191	-0.144	-0.816
	GT	-0.013	-0.254	0.068	0.101	1	-0.444	-0.013	-0.052
	R	-0.551	0.483	-0.049	0.191	-0.444	1	-0.012	-0.291
	IM	0.517	-0.029	0.028	-0.144	-0.013	-0.012	1	0.476
	CO2	0.179	-0.491	0.646	-0.816	-0.052	-0.291	0.476	1
Covariences		GDP	M	HI	HC	GT	R	IM	CO2
	GDP	0.13	0	-0.001	-0.001	-0.001	-0.015	0.037	0.001
	M	0	0	0	0	-0.001	0.001	0	0
	HI	-0.001	0	0.001	-0.001	0	0	0	0
	HC	-0.001	0	-0.001	0.003	0.001	0.001	-0.001	-0.001
	GT	-0.001	-0.001	0	0.001	0.059	-0.008	-0.001	0
	R	-0.015	0.001	0	0.001	-0.008	0.006	0	0
	IM	0.037	0	0	-0.001	-0.001	0	0.039	0.001
	CO2	0.001	0	0	-0.001	0	0	0.001	0

This study provides insights into the relationships between the variables. Most variables were found to be relevant, as indicated in Tables 4.1, 4.2, and 4.3.

Life expectancy was approximately 77.71 years, and the infant mortality rate was approximately 6.84. The population appears to enjoy a fairly stable health profile. However, concerns emerged with the data indicating incidence rates of 57.52% for heart illness and 36.9% for respiratory diseases, which suggests challenges in public health. This can be due to various environmental factors such as a variability global temperature of 0.77 and a methane level of 6. This also suggests the importance of monitoring climate-related variables. The average CO_2 level of 385.42 indicates a significant environmental impact, necessitating attention to sustainable practices. We can also see that the

86.955% of the population having some type of health-care coverage reflects a robust health-care system. We also have an economic landscape characterized by a 4.81% GDP growth rate, which complements the overall picture, emphasizing the correlation of health, environment, and economic factors in shaping societal well-being.

A closer inspection of the correlation matrix revealed that some notable correlations include a strong negative correlation between GDP and heart illness at −0.84, which suggests that as GDP increases, the prevalence of heart illness tends to decrease. Similarly, a robust negative correlation of −0.551 was observed between GDP and respiratory disease (*R*), indicating a potential improvement in respiratory health with economic growth. On the environmental front, a noteworthy positive correlation of 0.686 was found between CO_2 levels and heart illness, underscoring the environmental impact on public health. In addition, health-care coverage exhibits a strong negative correlation of −0.816 with both heart illness and CO_2 levels, emphasizing the vital role of health-care access in mitigating health and environmental challenges. These correlations provide a nuanced understanding of the intricate connections between economic, environmental, and health-care factors essential for informed policy decisions and comprehensive societal development.

Table 4.4: Model Summary and ANOVA

					Change statistics				
Model	R	R Square	Adjusted R square	St. Error of the estimate	Rquare change	F change	df1	df2	Sig F Change
1	0.978	0.956	0.94	0.312	0.956	59.401	8	22	0

Model	Sum of squares	df	Mean square	F	sig
regresion	46.246	8	5.781	59.401	0
residual	2.141	22	0.97		
Total	48.387	30			

The ANOVA table shows that the Model section focuses on the regression model's performance in explaining the dependent variable.

The *R*-squared value is a measure of how well the independent variables in the model explain the variability in the dependent variable. The *R*-squared values range from 0 to 1. In this case, 0 would indicate that the independent variables do not explain any of the variability in the dependent variable, and 1 being the opposite. In this study, we obtained a value of 0.96, which is strong. The F-value is a statistical measure that assesses the significance of the regression model. In our case, the F-value was 59.40, calculated by dividing the mean square of the model by the mean square of the residuals. A higher F-value indicates a stronger relationship between the predictors and the dependent variable.

In this case, the significance level of nearly 0.000 suggests that the p-value associated with the F-test was extremely low. A low p-value indicates that the regression model was statistically significant, implying that it provides a significant amount of explanation for the dependent variable beyond random chance.

4.1 Effect on Pension Funds

As we formulate a practical conclusion from these results, we look toward the economic sector. In this case, we examined pension funds. A lower life expectancy, a phenomenon marked by a decrease in the average and expected lifespan of a population, has significant implications for various sectors of society. One such area that is greatly affected by this trend is pension funds (Coppus, 2013).

Pension funds, designed to provide income security during retirement, face numerous challenges when individuals live shorter lives than anticipated. This study examined the effect of lower life expectancy on pension funds, considering its financial implications and the need for adjustments in planning and investment strategies (Catalán, 2004).

I. The financial impact: Lower life expectancy directly affects pension funds by altering the dynamics of their financial calculations. Traditionally, pension fund managers operate on the assumption that beneficiaries will live to a certain age. However, when life expectancy decreases, the time over which pension payments must be distributed also decreases. This in turn affects the fund's ability to generate income from investments and could potentially lead to a surplus of funds (Ngangue & Manfred, 2015).

According to a study by the Society of Actuaries (Jared, et al.,2023), a one-year decrease in life expectancy could result in a reduction of pension liabilities by approximately 1%. This reduction, though seemingly positive, can create challenges in managing funds and meeting future obligations. Pension fund managers must carefully analyze the impact of lower life expectancy on their financial projections and adjust their investment strategies accordingly.

II. Adjustments in Planning and Investment Strategies: With lower life expectancy, pension fund managers must adapt their planning, given the changes in the playing field, and investment strategies to ensure the long-term sustainability of the fund. Some things that they need to keep in mind could include the following:

a. Actuarial Assumptions: Pension fund managers rely on actuarial assumptions to estimate what is expected to be future pension obligations. In the case of lower life expectancy, these assumptions must be revisited to accurately reflect the changes that occur in the global life landscape. Adjusting mortality rates, life expectancies, and retirement ages in actuarial models would be a great help for the alignment between pension funds and their projections with new realities.

b. Investment Diversification: Pension funds are typically used as investments in various asset classes to generate returns. Owing to the lower life expectancy, fund managers would need to lower their investment mix and potentially shift toward “safer” investment options to mitigate risks associated with shorter payment periods. This means that they would need to generate a more diversified portfolio that balances risk and return, which becomes crucial to ensure stable income generation.

c. Longevity Risk Management: Longevity risk is the risk of pension payments continuing for longer than expected due to increased life spans, which would be less pronounced with lower life expectancy. Pension fund managers can explore various risk management techniques such as longevity swaps or annuity reinsurance to transfer or mitigate the impact of this risk on financial stability (De Waegenaere et al., 2010, p.158-192).

In conclusion, lower life expectancy poses significant challenges for the world of pension funds, requiring adjustments in planning and investment strategies due to the change in what was expected. The financial impact can be both positive and negative, as shorter life spans reduce pension liabilities but also affect the fund's ability to generate income for what was estimated. By revisiting actuarial assumptions, diversifying investments, and managing longevity risk, pension fund managers can navigate the changing landscape and ensure the long-term sustainability of retirement income for those who use them.

5. CONCLUSON, LIMITATIONS AND FUTURE WORKS

The interconnections between CC, lower life expectancy, and their impacts on pension funds are a critical considerations in today's world. CC has far-reaching consequences, including adverse effects on health, which can contribute to a decrease in life expectancy. As individuals live shorter lives, pension fund managers face significant financial implications and must adapt their strategies to ensure long-term sustainability (Bosello et al., 2006).

The link between CC and lower life expectancy is multifaceted. Increasing global temperatures and increased air pollution can lead to a higher incidence of respiratory diseases, cardiovascular issues, and heat-related illnesses. According to McMichael et al. (2012), these health risks, coupled with the spread of infectious diseases and food insecurity, contribute to a decline in overall life expectancy.

The implications for pension funds are significant. Lower life expectancy alters the financial calculations underlying pension funds because they are based on assumptions regarding life span. With shorter life spans, pension fund managers face the challenge of managing their financial resources over a reduced payout period. This can impact their ability to generate income from investments, potentially resulting in a surplus or shortfall of funds (Auerbach et al., 2017).

This essay can help in the process of informing policymakers in their decision-making. This research aims to provide evidence-based insights that can inform policymakers, financial institutions, and pension fund managers about the long-term implications of CC on retirement planning. By establishing the link between CC, lower life expectancy, and its impact on pension funds, the study shows the need for the development of more proactive measures and policies to safeguard retirement savings and ensure the sustainability of pension funds in an era of rapid environmental change. It is also a huge help in developing better CC adaptation strategies. By achieving the objectives of this research, this study raises awareness about the urgent need for comprehensive adaptation strategies that protect individuals' retirement savings in the face of an increasingly uncertain future. This objective will help in the development of adaptation policies and practices that integrate CC considerations into retirement planning frameworks.

Addressing the impact of CC on lower life expectancy and pension funds requires a multipronged approach. First, efforts to mitigate CC by reducing GHG emissions, transitioning to renewable energy sources, and implementing sustainable practices can help alleviate the health risks associated with the changing climate. By promoting public health, these measures can contribute to an improvement in life expectancy.

Moreover, pension fund managers must factor in the changing demographic landscape when developing long-term investment and planning strategies. This includes reassessing actuarial assumptions, diversifying investments, and implementing effective risk management techniques to ensure the stability and viability of pension funds in the face of evolving environmental and health challenges.

One major limitation of this study was that all data sets were available or complete. Another major limitation was that not all countries had extensive information on CC and therefore could not be observed. This is more prominent in developing countries. There were also issues in the recollection of data in terms of health and mortality rates by these countries. This was solved by emphasizing a country where all the data needed or wanted are available and organized, but it is important to highlight that the data limitation is a serious problem, as the countries most affected by CC lack reliable information primarily owing to their economic situation and social instability (Chinowsky et al., 2011). It is also important to note that correlation coefficients only measure linear relationships, and other types of relationships may exist between these variables that were not captured by the correlations.

For future work, it would be interesting to see this analysis performed on a more global scale, where we could see the full effect of CC and its relationship to human life. Moreover, I believe it would be interesting to see its effect not only on pension funds but also on other economic fields to really see how the butterfly effect carries on through other sectors.

In conclusion, the relationship between CC, lower life expectancy, and its impact on pension funds is undeniable. Addressing CC, improving public health outcomes, and adapting pension fund strategies are crucial steps in navigating the complex challenges posed by these interconnected issues. By recognizing and responding to this relationship, we can strive for a more sustainable future that safeguards the financial security and well-being of retirees in the face of a changing world.

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7. APPENDIX A

Table 7.1: Data

Year	Global Temperature	Methane	Co2	Heart illness	Respiratoy	Life expectancy	Infant Mortality	% covered by health care	Log GDP
1992	0.24	2.36	356.5	59.58	31.61	75.498	8.994	85	4.4051583
1993	0.36	3.83	357.92	60.99	32.01	75.65	8.674	84.70	4.42139485
1994	0.41	7.22	359.96	61.48	32.39	75.814	8.428	84.80	4.44239907
1995	0.51	3.96	361.67	62.22	33.57	75.978	8.182	84.60	4.4577438
1996	0.37	2.5	363.23	62.22	34.18	76.142	7.935	84.60	4.4766536
1997	0.41	6.27	365.28	62.09	34.81	76.306	7.689	84.30	4.49774683
1998	0.7	12.14	368.05	62.39	35.19	76.47	7.443	84.20	4.51658398
1999	0.37	2.4	368.93	63.47	35.64	76.612	7.353	86.40	4.53801279
2000	0.43	-1.48	369.83	63.3	36.47	76.754	7.263	86.90	4.56026487
2001	0.55	-0.72	371.42	62.61	37.8	76.896	7.173	86.50	4.56976733
2002	0.62	3.24	373.98	61.83	38.32	77.038	7.083	86.10	4.57975799
2003	0.63	4.79	376.17	60.3	38.66	77.18	6.993	85.40	4.59649016
2004	0.55	-4.86	377.68	57.84	38.9	77.382	6.951	85.70	4.62039251
2005	0.7	0.37	380.31	56.94	38.84	77.584	6.909	85.40	4.64466904
2006	0.66	1.91	382.02	55.41	38.29	77.786	6.868	84.80	4.66559976
2007	0.66	7.81	384.19	53.96	38.61	77.988	6.826	85.30	4.68169541
2008	0.55	6.56	385.79	53.18	38.37	78.19	6.784	85.10	4.68636851
2009	0.66	4.66	387.63	52.03	38.17	78.34	6.619	83.90	4.67389547
2010	0.73	5.2	389.99	51.46	38.4	78.49	6.454	83.70	4.68708859
2011	0.63	4.87	392.06	51.91	38.09	78.64	6.289	84.30	4.6995426
2012	0.66	5.01	394.57	52.09	37.77	78.79	6.124	84.60	4.7141991
2013	0.68	5.7	397.03	52.52	38	78.94	5.959	86.80	4.72665491
2014	0.77	12.77	399.08	53.16	37.96	78.914	5.93	89.60	4.74133954
2015	0.92	10.02	402.06	54.22	37.99	78.888	5.901	90.90	4.75406327
2016	1.03	7.1	404.64	54.99	37.94	78.862	5.873	91.20	4.76242905
2017	0.95	6.84	407	54.82	38.06	78.836	5.844	92.10	4.77748304
2018	0.87	8.7	409.27	56.23	38.01	78.81	5.815	91.50	4.79812081
2019	0.98	9.7	411.98	57.76	37.32	78.87	5.748	92	4.81371702
2020	1.01	15.21	414.26	57.76	37.42	78.93	5.681	91.40	4.80296952
2021	0.86	17.7	416.71	57.76	38	78.99	5.614	91.70	4.84645756
2022	0.91	14.07	418.95	57.76	37.82	79.05	5.547	92.10	4.88308535

Table 7.2: Units of measurements

Global temperature	variability
Methane	variability
Co2	average
Heart Illness	per million of habitants
Respiratoy conditions	per million of habitants
Life Expectancy	Expected Years
Infant Mortality	Deaths per 1000 Live Births
% covered by health care	Percentage of people in the US covered by health care
Log GDP	Log Per Capita (US $)