



## Socioeconomic determinants and impacts of life expectancy in the Democratic Republic of the Congo: A time series analysis from 1960-2020

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**Abstract:** *Purpose:* This study aims to identify the socioeconomic determinants and impacts of life expectancy in the Democratic Republic of the Congo (DRC) from 1960-2020.

*Methodology:* Using time series data from the World Bank, correlation analysis and Granger causality tests are employed to examine relationships between life expectancy and various macroeconomic indicators in the DRC.

*Results:* Inflation, economic growth, population growth, and CO<sub>2</sub> emissions are the causes of life expectancy in the DRC. In turn, life expectancy Granger causes inflation, economic growth, mineral rents, and CO<sub>2</sub> emissions. A negative correlation is observed between mineral rents and economic growth, while inflation negatively impacts life expectancy.

*Theoretical Contribution:* The bidirectional causality between economic growth and longevity in the DRC supports human capital theory. The study provides new evidence on the drivers and effects of life expectancy in the context of a developing, resource-rich economy.

*Practical Implications:* The findings suggest that the DRC government should prioritize spending on health and education to promote longevity as an economic development engine. Policies controlling inflation and sustaining mineral resources are also crucial for improving life expectancy.

**Keywords:** endogenous economic growth, human capital, Granger Causality test, life expectancy,



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natural resource curse, climate change, mineral rents, Democratic Republic of the Congo

**Sustainable Development Goals (SDGs): SDG 3:** Good Health and Well-being; **SDG 1:** No Poverty; **SDG 10:** Reduced Inequalities; **SDG 9:** Industry, Innovation and Infrastructure; **SDG 11:** Sustainable Cities and Communities

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## 1. Introduction

The causal relationship between the health of a population and economic development (growth) has attracted increasing attention in the economic literature over the last two decades (Miladinov, 2020; Hansen & Lonstrup, 2015; Bloom et al., 2014; Aghion, Howitt & Murtin, 2011). The population's health, measured by life expectancy, is one of the government's most important goals. Life expectancy at birth is the average number of years a newborn can expect to live. Since it is an average, some people will die very young, and others will live over 100 years.

The longevity depends on several factors, including medical advances (better care for pregnant women and infants, new drugs and vaccines, and surgical innovation), reductions in abject poverty (access to clean drinking water, better nutrition, etc.), and technological progress (refrigerators, electricity, heating, etc.). The factors are influenced by personal choices that may reduce life expectancy, such as smoking. Life expectancy is the years people usually live before death, not because of accident or injury, but because people die at a certain age in that population. Life expectancy can estimate a nation's average years of living if the men live longer than the women and other factors. According to the Human Development Indices (HDI) report, the life expectancy rate at birth is calculated using a maximum value of 83 years and a minimum of 20 years. For a country with a life expectancy birth rate of 55 years, 0.551 would be the life expectancy rate.

In an ideal world, an increase in life expectancy would be driven primarily by increases in years lived in good health, with a shrinking proportion of years lived in disability. This would mean that people live longer and remain in good health for extended periods and more significant proportions of their lives (WHO, 2022). Significant investments and improvements in AIDS, TB, and malaria programs have led to declines in incidence and mortality for these diseases at the global level.

Cross-studies show a strong correlation between measures of life expectancy and both the level of economic development and recent economic growth, and these studies have not established a causal effect of health and disease on economic growth (Acemoglu and Johnson, 2007). Since countries suffering from short life expectancy and ill health are also disadvantaged in other ways (often this is the reason for their poor health outcomes), such macro studies may capture the adverse effects of these other, often omitted, disadvantages (Acemoglu & Johnson, 2007).

The main objective of this study is to identify the causes and consequences of longevity. This work will answer the following question. What socioeconomic factors cause longevity in the Democratic Republic of the Congo? To do so, we use two statistical tools: covariance analysis and Granger causality analysis. Researchers in social sciences widely use these tools because they are easy to use, compute, and interpret.

The contribution of this study is based on two views: theoretical and practical. From a theoretical view, this study will contribute to the development of human capital theory by providing some causal variables of longevity. This study gives some key macroeconomic, environmental, and climate change variables that cause longevity and the consequences of longevity in the DRC. By using the data from the Democratic Republic of the Congo, we investigate the new world characterized by poverty in the majority of the population, high unemployment rate, full dollarization, tropical region, persistence of armed conflicts, and natural resources.

To answer these questions, we use two analyses. First, we use the correlation analysis to the DRC's data for verifying natural resource curse hypothesis and the relationship between life expectancy and economic growth. Finally, the Granger causality analysis aims to identify the drivers and effects of life expectancy in the DRC.

The structure of the remainder of the paper is as follows. Section I begins the analysis by discussing the recent changes in the cross-sectional relationship between income, life expectancy, fertility, and schooling. Section II presents the related works on the relationship between life expectancy and socioeconomic development. Section III presents the econometric methodology used in this study based on the Granger causality analysis. Section IV gives the empirical results from the econometric approach and data. In Section V, we discuss the empirical results.

## 2. Literature review

This section gives a short literature review of the topic, subdivided into two subsections. It gives the related works and the motivated theory.

### 2.1. Related works

Kabir (2008) develops a model where reductions in mortality are the main force behind economic development. The model generates a pattern of changes similar to the demographic transition, where gains in life expectancy at birth are followed by reductions in fertility and increases in the rate of human capital accumulation. The onset of the transition is characterized by a critical level of life expectancy at birth, which marks the movement of the economy from a Malthusian equilibrium to an equilibrium with investments in human capital and the possibility of long-run growth.

Wilkinson (1996) found that the health of a population is directly related to its average income, at least for populations with a per capita GDP below a threshold of 5,000 USD - 10,000 USD, and no consistent relation above that. On the other hand, in a cross-country comparison, Anand and Ravallion (1993) found a significant positive association between per capita GNP and life expectancy, which worked mainly through the impact of national income on the poor's income and public expenditure, specifically on health. However, when they considered poverty and public expenditure on health as explanatory variables, the relationship between per capita GNP and life expectancy disappeared. However, Sen (1999) reveals that the Indian state of Kerala has achieved impressively high life expectancy despite its low per capita income.

Veugelers and Kephart (2001) have identified many important proximate determinants of health but have given little emphasis to the importance of poverty, income inequality, cultural disruption, social environment, and socioeconomic neighborhood characteristics. They have used individual and multi-level logistic regressions for Canada and found lower mortality rates among well-educated people; within advantaged neighborhoods, the importance of education for mortality was increased compared to disadvantaged ones.

Guralnik (1993) found that black men had lower life expectancy than white, but education had a substantially more substantial effect on life expectancy than race. Williamson and Boehmer (1997) used multiple regression and cross-section analysis from 40 to 97 countries and have shown that women's educational status positively and significantly impacts female life expectancy.

However, Rogot, Sorlie, and Johnson (1992) have estimated determinants of life expectancy for white men and women in the US by education, family income, and employment status and have revealed that life expectancy varies directly with years of schooling. In a multivariate linear regression analysis of data from 156 countries, Gulis (2000) found that literacy had a statistically significant role in explaining life expectancy. Rogers and Wofford (1989) examined life expectancy for 95 developing countries against six indicators of modernization: (i) the percentage of the population living in urban areas, (ii) the percentage of the population engaged in agriculture, (iii) the percentage of the population who are illiterate, (iv) percentage of population without access to safe drinking water, (v) per capita daily calorie intake, and (vi) population per physician. The result shows that literacy significantly explains the variation in life expectancy.

One would, however, expect a positive relationship between healthcare spending and health status if increasing resources implies an improvement in the level and quality of health services supplied to the population. There may also be diminishing returns to scale above some level of expenditure.

Hitiris and Posnett (1992) found a slight negative relationship between health spending and mortality rates. Based on a richer model in terms of explanatory variables but with fewer countries, Grubaugh and Santerre (1994) found a positive impact of specific health inputs like the number of doctors and hospital beds on health measured by infant mortality rates. Hadley (1982), using mortality data from the United States, shows a positive relationship between health expenditure and health. Other studies have found that there is a positive relationship between healthcare input and health outcomes in the context of Europe (see Collins and Klein (1980); Forbes and McGregor (1984); and Elola, Daponte, and Navarro (1995)).

Lorentzen, McMillan, and Wacziargb (2008) used cross-country (longitudinal) data and found evidence for higher life expectancy leading to faster economic growth. On the other hand, Acemoglu and Johnson (2007) find that life expectancy improvements lead to some growth in aggregate incomes but mainly trigger faster population growth and, therefore, have a negative causal effect on income per capita.

Access to safe drinking water is also essential in determining life expectancy in developing countries. In the mid-twentieth century, many African and Asian countries experienced dramatic improvements in life expectancy brought about by, among others, access to safe water. By using multivariate linear regression analysis on data from 156 countries, Gulis (2000) found that, among access to safe drinking water, per capita GDP, literacy, calorie intake, and per capita public health expenditure, access to safe drinking water had a statistically significant role in explaining life expectancy.

As noted above, inflation expectations are central to modern monetary policy, and managing consumers' inflation expectations has become one of the main goals of central banks (Bernanke, 2004). However, managing inflation expectations requires monitoring expectations and understanding how these expectations are formed and revised in response to new information. Several models have been proposed to explain the cross-sectional variation in consumers' inflation expectations, but there is little direct evidence on how individual consumers form their inflation expectations.

With few exceptions (Anderson (2008) and Souleles (2004)), previous work has analyzed the aggregate evolution of beliefs and has not studied the actual updating at the individual consumer level, which leads to ambiguous interpretations of the findings of previous work on learning in expectation updating. Similar patterns are held by gender, income, and age such that these groups' inflation expectations converge across demographic groups after the information treatment.

Thus, we offer an alternative explanation for specific demographic groups' systematically high inflation expectations by identifying a relative gap in their own information sets regarding objective inflation measures. This suggests a potential role for policies incorporating public information campaigns to effectively control the high-expectation right tail of the public's inflation expectations distribution. Because keeping consumers' inflation expectations anchored is generally essential for controlling inflation, public information campaigns about past and current inflation may have a role in prudent monetary policy.

Bachmann, Berg, and Sims (2015) have suggested that the monetary policy is an engineer of higher inflation expectations to stimulate spending. They examined the relationship between expected inflation and spending attitudes using the Michigan Survey of Consumers microdata. They have found that the impact of higher inflation expectations on the reported readiness to spend on durables is generally tiny, outside the zero lower bound, often statistically insignificant, and inside of it, typically significantly negative. That is, a one percentage point increase in expected inflation during the recent zero lower bound period reduces households' probability of having a positive attitude towards spending by about 0.5 percentage points.

Beechey, Johannsen, and Levin (2011) compare the evolution of long-run inflation expectations in the euro area and the United States, using evidence from financial markets and surveys of professional forecasters. They found that long-run inflation expectations are reasonably well anchored in both economies but reveal substantially greater dispersion across forecasters' long-horizon projections of US inflation. Daily data analysis on inflation swaps and nominal-indexed bond spreads, which gauge compensation for expected inflation and inflation risk, also suggests that long-run inflation expectations are more firmly anchored in the euro than in the United States. Their findings are also similar to that of Gurkaynak, Levin, and Swanson (2006), who found that long-run inflation expectations are not as firmly anchored in the United States as in several inflation-targeting countries, namely, Canada, Sweden, and the United Kingdom. However, those studies left open the possibility that these results might reflect other systematic differences between small open economies versus large and relatively closed economies.

Gains in adult longevity are significant because they increase the horizon over which benefits from investments in human capital can be enjoyed, increasing the returns to education. This eventually raises educational attainment and increases the productivity of individuals in the labor market and the household sector. In addition, higher adult longevity reduces the benefits of having a

large number of children, shifting the quantity-quality trade-off toward fewer and better-educated offspring. Lower fertility and higher investments in children and adults lead to faster human capital accumulation and higher growth. On the other hand, reductions in child mortality affect only the benefits of having a large family. With more children surviving childhood, it becomes less valuable to have many children and relatively more attractive (or cheaper) to invest more in each surviving child.

Higher investments in human capital during childhood mean that children face higher productivity from later investments in education and become more productive adults, even when educational attainment remains unchanged. In this case, lower fertility and higher investments in children lead to faster human capital accumulation and, again, higher growth.

Low socioeconomic status is considered a risk (Rogers and Wofford 1989). Hahn (1995) attributes 17 United States to poverty in one study. In their sample, people with low incomes are

likely to marry, less likely to exercise, but under most pressure, and to be obese. Most importantly, they are more likely to experience poverty than males, to suffer from poverty. Among both blacks, the mortality rate for men was twice as large as that; similarly, numerous other studies have shown mortality and socioeconomic status (as the measure is more vital for men than for women 20 suggests that poverty does not impact women or men. For example, poverty is associated with child survival in India the most during famine.

The resource curse is a well-known, widely debated concept in the international development literature. The resource curse hypothesis says that citizens of countries with natural resource abundance tend, ironically, to have lower rates of income growth and social well-being (see Gelb (1988), Auty (1995), Auty(1993), Sachs and Warner (2001), Auty and Furlong (2019)). However, some recent work provides data to suggest that the resource curse may be less pronounced than widely thought or even incorrect (Brunnschweiler and Bulte, 2008).

Brunnschweiler and Bulte (2008) have contradicted the resource curse theory by finding positive correlations between resource abundance and economic growth. These correlations are particularly pronounced for subsoil wealth. Indeed, unexpected inflation has an effect that is more pernicious than any of the costs of steady, anticipated inflation: it arbitrarily redistributes wealth among people. One cost is the distorting effect of the inflation tax on the amount of money people hold. As we have already discussed, a higher inflation rate leads to a higher nominal interest rate, leading to lower accurate money balances. The inconvenience of reducing money holding is metaphorically called the shoe-leather cost of inflation because walking to the bank often causes one's shoes to wear out more quickly. A second cost of inflation arises because high inflation induces firms to change their posted prices more often. Changing prices is sometimes costly; for example, it may require printing and distributing a new catalog.

These costs are called menu costs because the higher the inflation rate, the more often restaurants have to print new menus. A third cost of inflation arises because firms facing menu costs change prices infrequently; therefore, the higher the inflation rate, the greater the variability in relative prices.

If there is no inflation, the firm's prices relative to the overall price level are constant over the year—a fourth cost of inflation results from the tax laws. Many provisions of the tax code do not consider the effects of inflation. Inflation can often alter individuals' tax liability in ways that lawmakers did not intend. A fifth cost of inflation is the inconvenience of living in a world with a changing price level. Money is the yardstick with which we measure economic transactions. When there is inflation, that yardstick is changing in length. For example, a changing price level complicates personal financial planning. An important decision that all households face is how much of their income to consume today and how much to save for retirement.

Most loan agreements specify a nominal interest rate, which is based on the rate of inflation expected at the time of the agreement. If inflation turns out differently from what was expected, the ex post real return that the debtor pays to the creditor differs from what both parties anticipated. On the one hand, if inflation is higher than expected, the debtor wins, and the creditor loses because the debtor repays the loan with less valuable dollars. On the other hand, if inflation turns out to be lower than expected, the creditor wins, and the debtor loses because the repayment is worth more than the two parties anticipated. Unanticipated inflation also hurts people on fixed pensions. Workers and firms often agree on a fixed nominal pension when the worker retires (or earlier).

Because the pension is deferred earnings, the worker essentially provides the firm a loan: the worker provides labor services while young but does not get fully paid until old age. Like any creditor, the worker is hurt when inflation increases. Like any debtor, the firm is hurt when inflation is lower than anticipated. These situations provide an evident argument against variable inflation. The more variable the rate of inflation, the greater the uncertainty that both debtors and creditors face. Because most people are risk averse --- they dislike uncertainty --- the unpredictability caused by highly variable inflation hurts almost everyone.

Crepaz and Crepaz (2004) found that the life expectancy of populations is driven by factors such as perceived political control, the generosity of the welfare state, lifestyles, GDP per capita, and the poverty rate. Independently of which measure of income inequality was used or which statistical method was applied, these findings remained robust even when several alternative explanations were controlled. Most political scientists who study the consequences of income inequality would describe statements such as 'Is our society making you sick?' or 'Is inequality bad for your health?' Daniels, Kennedy, and Kawachi (2004) as rather startling. However, public health professionals and epidemiologists have been arguing for more than two decades that health and longevity are significantly mediated by the socio-political environment, leading Stephen Bezruchka, a Medical Doctor at the University of Washington's School of Public Health, to declare that 'the most critical risk factor is the gap between the rich and the poor (Bezruchka, 2000).

The planet comprises many different ecosystems. Examples include mountain and polar, forest and woodland, inland water, drylands, cultivated land, urban land, coastal, island, and marine. Each ecosystem provides services to human populations in various forms (see Mooney (1996)). For example, polar ecosystems and mountains provide erosion control, food, fresh water, climate regulation, fiber, recreation and ecotourism, and aesthetic and spiritual values. Our various ecosystems on Earth provide us with the basics (e.g., the food we eat, the freshwater we drink, and the biofuels we use).

However, many other services provided by the various ecosystems are beyond providing essential resources. These involve supporting services such as nutrient cycling, soil formation, and primary production and system regulation like climate regulation, food regulation, disease regulation, pest regulation, and water purification. Also, ecosystems provide other cultural, social, and economic benefits through recreation and tourism, cultural heritage, and aesthetic and spiritual values.

Collectively, ecosystem services satisfy many human needs, such as security (e.g., personal safety, secure resource access, and security from disasters), the primary material for a good life (e.g., adequate livelihoods, sufficient nutritious food, shelter, and access to goods), health (e.g., strength, feeling well, and access to clean air and water), good social relations (e.g., social cohesion, mutual respect, and ability to help others), and freedom of choice and action (i.e., the opportunity to achieve what individual values doing and being).

Positive effects on environmental well-being regarding food production, water use, and sanitation can be discussed. The food supply has increased significantly to feed and lift people out of poverty. It is estimated that the total food production increased by about two-and-a-half times between 1960 and 2000 while the world population has doubled (from 3 billion to 6 billion)—most agricultural land and techniques produced far more crops and meat to feed the masses than ever. We have also seen a dramatic increase in fish and shellfish farming. This type of farming accounts for more than a third of the fish and shellfish production globally (Balmford and Bond 2005); Parris and Kates (2003); Millennium Ecosystem Assessment (2005).

Concerning water use and sanitation, it is estimated that since 1960, the ratio of water use to accessible supply has grown by 20% per decade. Problems of malnutrition, infant mortality, and diseases have been significantly reduced through efforts to provide people with a sufficient supply of uncontaminated water Balmford and Bond (2005); Goodstein and Polasky (2005); Kesler and Simon (2016); Millennium Ecosystem Assessment, 2005).

## 2.2. Motivated theory: Endogenous economic growth

We derive the medium - and long-run implications of increased life expectancy in the closed-economy neoclassical (Solow) growth model. Land and labor are supplied inelastically. We use some significant variables related to social conditions regarding the bird's life expectancy. The economy has the constant returns to scale aggregate production function.

$$y_t = (A_t H_t)^\alpha K_t^\beta L_t^{1-\alpha-\beta}, \quad (1)$$

where  $\alpha + \beta = 1$ ,  $K_t$  denotes capital,  $L_t$  denotes the supply of land and  $H_t$  is the practical units of labor given by  $L_t = h_t N_t$ , where  $N_t$  denotes a total population (and employment) and  $h_t$  denotes a human capital per person. Without loss of generality, we normalize  $L_t$  for all t.

Let us assume that life expectancy may increase output (per capita) through various channels, including more rapid human capital accumulation or direct positive effects on total factor productivity (TFP). To capture these effects in a reduced - form, we assume the following isoelastic relationships:

$$A_t = \bar{A} X_t^\delta, \quad (2)$$

$$H_t = \bar{h} X_t^\eta, \quad (3)$$

where  $X_t$  is life expectancy at time t, and  $\bar{A}$  and  $\bar{h}$  designate the steady - state of  $A_t$  and  $H_t$  respectively. Finally, greater life expectancy leads to a more significant population (both directly and potentially indirectly by increasing total births as more women live to childbearing age). First, suppose that while life expectancy changes (population, productivity, and human capital per worker change), the total capital stock remains fixed.

### 3. Methodology

In social science, the Granger analysis is one of the most popular decision-making tools in the private and public sectors. Governments and central banks, firms and consumers, financial institutions and banks base many of their decisions on future expected socioeconomic conditions or the predictions of specific indicators of interest such as longevity, income growth, inflation, unemployment, interest rates, exchange rates, earnings, wages, oil prices, and so on. Unfortunately, socioeconomic outcomes are the realization of a vast, complex, dynamic, and stochastic system, which makes forecasting very difficult and forecast errors unavoidable.

However, forecast reliability and precision can be enhanced using proper econometric models and methods, like those developed by C.W.J. Granger (1969). The Granger causality is pairwise because it combines two variables. The definition of Granger causality is based on two fundamental principles: (i) the cause occurs before the effect; (ii) the causal series contains unique information about the series being caused that is not available in the other available series.

This definition is the so-called 'in mean' definition introduced by Granger (1963). The 'in mean' definition implied that if  $y_t$  causes  $x_t$ , then  $x_{t+1}$  is better forecast if the information in  $y_{t-j}$  is used, then if it is not used, 'better' means a smaller variance of forecast error or the matrix equivalence of variance.

Let  $X_t$  and  $Y_t$  be two stationary time series with zero means. We use the bivariate VAR(p) defined as follows:

$$\begin{bmatrix} x_t \\ y_t \end{bmatrix} = \begin{bmatrix} \psi_{11}^1 & \psi_{12}^1 \\ \psi_{21}^1 & \psi_{22}^1 \end{bmatrix} \begin{bmatrix} x_{t-1} \\ y_{t-1} \end{bmatrix} + \begin{bmatrix} \psi_{11}^2 & \psi_{12}^2 \\ \psi_{21}^2 & \psi_{22}^2 \end{bmatrix} \begin{bmatrix} x_{t-2} \\ y_{t-2} \end{bmatrix} + \dots + \begin{bmatrix} \psi_{11}^p & \psi_{12}^p \\ \psi_{21}^p & \psi_{22}^p \end{bmatrix} \begin{bmatrix} x_{t-p} \\ y_{t-p} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix} \quad (4)$$

where  $u_{1t}$  and  $u_{2t}$  are taken to be two uncorrelated white-noise series, i.e.,  $E(u_{1t}u_{1s}) = 0$ ,  $E(u_{2t}u_{2s}) = 0$ , and  $E(u_{2t}u_{1s}) = 0$ ,  $t \neq s$ .

The parameters of this model are estimated by using the maximum likelihood method.

In the Granger causality test, we test  $y_t$  causes  $x_t$  the null hypothesis  $H_0: \psi_{12}^j = 0$ ,  $j=1, \dots, p$ , against the alternative hypothesis,  $H_a: \psi_{12}^j \neq 0$ , is rejected. We can also test  $x_t$  causes  $y_t$  if  $H_0: \psi_{21}^j = 0$ ,  $j=1, \dots, p$ , against the alternative hypothesis,  $H_a: \psi_{21}^j \neq 0$ , is rejected. Thus, the Fisher statistic type associated with each hypothesis is calculated and tested.

### 4. Empirical results

This section presents the main results using the correlation analysis, the causality analysis, and the policy implications. First of all, it begins by describing the data.

#### 4.1. Data

This section describes the data set for the Democratic Republic of the Congo from the World Development Indicators of the World Bank. We analyze the period from 1960 to 2020. To investigate the sources and effects of life expectancy of the DRC people, this study uses nine vital macroeconomic variables that sum up the Congolese economic characteristics. These are the arable land (AL), total reserves (RES), mineral rents (MIN), agricultural land (LANAGR), Gross domestic products (GDP), Life expectancy (EXP), Consumer prices index (CPI), and carbon dioxide (CO2) emissions. The DRC economy is small and open and one of the poorest countries. It is a naturally rich country with the Congo basin and a predominant mining sector. To get stationary data, all the data are logarithm-differenced, which means that  $\Delta X_t = \text{Log}X_t - \text{Log}X_{t-1}$  is the growth rate of X at the time t. These are the arable land (ARLAN), total reserves (RES), mineral rents (MIN), agricultural land (LANAGR), Gross domestic products (GDP), Life expectancy (EXP), Consumer prices index (CPI), and carbon dioxide (CO2) emissions. The DRC economy is small and open and one of the poorest countries. It is a naturally rich country with the Congo basin and a predominant mining sector.

#### 4.2. Results

The results of this study are given by using correlation analysis and the Granger causality test. The correlation analysis uses correlation coefficients that give the degree of association between two variables. Indeed, the correlation coefficient is a statistical measure of the strength of a linear relationship between two variables. Its values can range from -1 to 1. A correlation coefficient of -1

describes a perfect negative, or inverse, correlation, with values in one series rising as those in the other decline and vice versa. A coefficient of 1 shows a perfect positive correlation or a direct relationship. A correlation coefficient of 0 means there is no linear relationship.

**Table 1: Descriptive statistics**

| Statistics | AL    | RES   | POP  | MIN   | LA    | GDP   | EXP   | CPI   | CO <sub>2</sub> |
|------------|-------|-------|------|-------|-------|-------|-------|-------|-----------------|
| Mean       | 0.01  | 0.04  | 0.03 | -0.02 | 0.01  | 0.04  | 0.01  | 0.68  | -0.01           |
| Median     | 0.00  | 0.00  | 0.03 | 0.02  | 0.01  | 0.07  | 0.01  | 0.03  | 0.02            |
| Maximum    | 0.49  | 2.59  | 0.04 | 1.32  | 0.16  | 1.40  | 0.02  | 5.48  | 0.41            |
| Minimum    | -0.04 | -1.43 | 0.02 | -1.87 | -0.02 | -0.94 | -0.01 | -0.03 | -0.60           |
| Std Dev.   | 0.07  | 0.59  | 0.01 | 0.65  | 0.02  | 0.03  | 0.01  | 1.06  | 0.19            |
| Skewness   | 7.12  | 1.12  | 0.51 | -0.54 | 6.76  | 0.47  | 0.13  | 2.72  | -0.80           |
| Kurtosis   | 52.3  | 7.90  | 2.64 | 3.53  | 49.28 | 11.03 | 3.47  | 10.72 | 4.66            |
| JB stat    | 6254  | 72    | 2.89 | 2.94  | 5520  | 164   | 0.71  | 197   | 13              |
| Obs        | 57    | 60    | 60   | 49    | 57    | 60    | 59    | 53    | 58              |

The Jarque - Bera statistic in Table 1 shows that agricultural land, total reserves, arable land, CPI, and CO<sub>2</sub> follow no normal distribution, while population growth, mineral rents, and life expectancy growth follow the normal distribution.

**Table 2: Correlation analysis**

| Variable        | ARLAN | CO <sub>2</sub> | CPI          | EXP          | GDP   | LANAGR | MIN   | POP   | RES |
|-----------------|-------|-----------------|--------------|--------------|-------|--------|-------|-------|-----|
| ARLAN           | 1     |                 |              |              |       |        |       |       |     |
| CO <sub>2</sub> | 0.03  | 1               |              |              |       |        |       |       |     |
| CPI             | -0.11 | <b>-0.38*</b>   | 1            |              |       |        |       |       |     |
| EXP             | 0.07  | <b>0.26*</b>    | -0.56        | 1            |       |        |       |       |     |
| GDP             | 0.05  | -0.05           | -0.23        | 0.17         | 1     |        |       |       |     |
| LANAGR          | 0.99  | 0.06            | -0.14        | 0.10         | 0.07  | 1      |       |       |     |
| MIN             | -0.04 | 0.60            | -0.27        | <b>0.33*</b> | -0.35 | -0.07  | 1     |       |     |
| POP             | 0.16  | -0.16           | <b>0.40*</b> | 0.20         | -0.01 | 0.18   | -0.16 | 1     |     |
| RES             | 0.07  | -0.10           | -0.05        | 0.17         | -0.12 | 0.07   | 0.22  | -0.01 | 1   |

Using correlation analysis, we find out that there is a significant negative correlation between (i) life expectancy growth and inflation, (ii) mineral rents and economic growth, (iii) inflation and carbon dioxide growth. And a significant positive correlation between (i) carbon dioxide growth and life expectancy growth, (ii) mineral rents and carbon dioxide growth; (iii) mineral rents and life expectancy growth; (iv) population growth and inflation.

**Table 3: Causality Analysis**

| Cause             | Granger Causality Test | Effect            | Sample size | F - stat | p-value |
|-------------------|------------------------|-------------------|-------------|----------|---------|
| DLARLAND          | ----->                 | DLCO <sub>2</sub> | 54          | 5.30     | 0.00    |
| DLLANAGR          | ----->                 | DLARLAND          | 54          | 8.76     | 0.00    |
| DLARLAND          | ----->                 | DLLANAGR          | 54          | 9.10     | 0.00    |
| DLRES             | ----->                 | DLARLAND          | 54          | 9.72     | 0.00    |
| DLCO <sub>2</sub> | ----->                 | DLCPI             | 55          | 3.44     | 0.00    |
| DLEXP             | ----->                 | DLCO <sub>2</sub> | 55          | 3.85     | 0.02    |
| DLLANAGR          | ----->                 | DLCO <sub>2</sub> | 54          | 5.45     | 0.00    |
| DLCO <sub>2</sub> | ----->                 | DLPOP             | 54          | 2.20     | 0.10    |
| DLEXP             | ----->                 | DLCPI             | 50          | 3.48     | 0.02    |
| DLCPI             | ----->                 | DLEXP             | 50          | 3.48     | 0.02    |
| DLMIN             | ----->                 | DLCPI             | 50          | 3.92     | 0.02    |
| DLPOP             | ----->                 | DLCPI             | 50          | 4.33     | 0.00    |
| DLCPI             | ----->                 | DLPOP             | 50          | 3.98     | 0.01    |
| DLRES             | ----->                 | DLCPI             | 50          | 2.64     | 0.06    |
| DLGDP             | ----->                 | DLEXP             | 56          | 5.01     | 0.00    |
| DLEXP             | ----->                 | DLGDP             | 50          | 2.45     | 0.07    |
| DLEXP             | ----->                 | DLMIN             | 50          | 4.09     | 0.01    |
| DLPOP             | ----->                 | DLEXP             | 56          | 2.51     | 0.07    |
| DLMIN             | ----->                 | DLGDP             | 46          | 2.44     | 0.08    |
| DLRES             | ----->                 | DLLANAGR          | 54          | 10.63    | 0.00    |
| DLPOP             | ----->                 | DLMIN             | 46          | 2.30     | 0.09    |
| DLMIN             | ----->                 | DLPOP             | 46          | 5.17     | 0.00    |

### 4.3. Determinants of longevity

For the question, what Granger causes the life expectancy in the DRC? Using the Granger causality test, we get eight drivers as the CPI - inflation, economic growth, international reserves growth, mineral rents growth, land agricultural growth, population growth, and arable land growth. The economic literature can drive the explanation of these causality relationships.

Economic growth generally increases life expectancy because the government has much money to reduce poverty by funding the social sector, especially health, transportation, education, etc. In a democratic society, high economic growth is always followed by high income, health, and education. Thus, high economic growth is positively correlated with high longevity. However, it is observed in developing countries that the co-movement between high economic growth and lower longevity is due to corruption and lousy income redistribution policies. Thornton and Philipov (2009) found that a critical goal of the socialist program was transforming the economy and society through intensive industrialization that would rapidly bring economic productivity, education, health, and equality in the region up to and beyond.

**Population growth causes longevity.** The theory predicts that improvements in life expectancy primarily increase population before the demographic transition. Improvements in life expectancy do, however, reduce population growth and foster human capital accumulation after the onset of the demographic transition. Cervellati and Sunde (2011) argued that the effect of life expectancy on population, human capital, and income per capita is not the same before and after the demographic transition.

**Climate change causes longevity.** Carbon dioxide emissions are the primary driver of global climate change. It's widely recognized that to avoid the worst impacts of climate change, the world needs to reduce emissions urgently. But, how this responsibility is shared between regions, countries, and individuals has been an endless point of contention in international discussions. To capture the effect of environmental degradation on longevity, we include CO2 emissions from World Development indicators of the World Bank. Apte et al. (2018) find that air pollution reduces life expectancy by more than a year.

On the other hand, Bayati, Akbarian, and Kavosi (2013), in a study on the determinants of life expectancy in the Eastern Mediterranean countries, found that CO2 emissions are insignificantly related to life expectancy. Echert and Kohler (2014) found a control for the share of the urban population from the World Bank to account for the relationship between demographic structure and health. For example, urbanization is positively associated with health in developing countries. Moreover, Singh and Siahpush (2014) find that the gap between urban and rural life expectancies in the United States exceeds 3 years. Finally, we add health spending as a percent of GDP and HIV/AIDS prevalence rate as they have been related to life expectancy in cross-country research like in Kim and Lane (2013).

**The inflation rate causes the life expectancy.** Indeed, there are seven social costs. The first five are negative and occur whether or not inflation was expected. (i) By increasing the demand for a constant money supply, inflation increases interest rates, deterring investment. (ii) Reducing the actual value of aggregate consumer wealth inhibits consumer spending. (iii) Raising effective tax and reducing real government purchases makes fiscal policy more restrictive. (iv) Raising domestic prices relative to foreign inhibits exports and stimulates imports. (v) By increasing consumer fear and feeling of insecurity, it increases the propensity to save. (vi) Increasing expected future output prices relative to current costs of capital goods encourages investment. (vii) By encouraging purchases now instead of later, it moves investment and consumption forward in time (Ackley (1978), Pfajfar and Santoro (2013)).

In the 1990s, the DRC is one of the countries affected by hyperinflation and great recession. For nearly three decades, the D.R. Congolese have been scarred by the traumatic experience of inflation in the 1990s, placing price stability at the top of its list of economic priorities, such as the Central Bank of Congo's mandate, due to fears of economic collapse and political instability.

During this period, the government could not pay salaries to its employees, buy social goods, and spend money on education and health. Indeed, major economic concerns, such as hyperinflation, resulted from the dollarization of the DRC's economy. In sum, the inflation rate can reduce the life expectancy.

**Mineral rent growth causes longevity.** Extracting natural resources such as minerals, oil, and gas can drive economic growth, reduce poverty, and promote sustainable development. Instead, mining activity positively impacts incomes, housing affordability, communication access, education, and employment across regional and remote Australia.

#### 4.4. Consequences of longevity

Using the Granger causality, we find that life expectancy causes inflation, mineral rents, carbon dioxide, and economic growth. First, longevity increases population growth and inflation. When the population increases due to improving health, the demand for goods and services will also increase; therefore, the prices of these goods and services will increase when the supply stays unchangeable. Second, life expectancy causes the growth of CO<sub>2</sub> emissions because of population growth.

#### 4.5. Policy implications and risk factors of health in the DRC

These results argue that increases in longevity increase both investments in adults and the stock of essential human capital that children receive. Higher primary human capital and more investments in adult education (higher educational attainment) increase the accumulation of human capital from one generation to the next, increasing the economy's growth rate. Higher adult longevity affects investments in education and fertility, so the quantity-quality trade-off is tilted toward fewer and better-educated children.

Higher investments in adult education lead to a situation where human capital is accumulated at a higher rate and, therefore, the economy grows faster. In recent debate, six sets of factors have frequently been invoked to account for Africa's poor economic performance: (i) external conditions: the legacy of centuries of slave trading and colonial rule, as well as the manipulation of African politics during the Cold war; (ii) heavy dependence on a small number of primary exports, with declines and volatility in terms of trade; (iii) internal politics: characterized by authoritarianism, corruption, and political instability; (iv) economic policies: protectionism, statism, and fiscal profligacy; (v) demographic change: in particular, rapid population growth; and (vi) social conditions: deep ethnic divisions, indicated by high levels of ethnolinguistic and religious diversity and low levels of 'social capital' (Bloom et al., 1998).

There are some risk factors for health, such as malnutrition, alcohol consumption and tobacco use, basic hygiene, clean fuels and technologies for cooking, obesity, anemia, hypertension among adults, violence against women, air pollution, road traffic injuries, mental health, and unsafe water. According to the reports of some non-government organizations (NGOs), in some regions of the DRC, like the Grand Kasai, the people are suffering from malnutrition. Indeed, malnutrition refers to deficiencies, excess or imbalance in a person's energy and/or nutrient intake. It manifests in undernutrition (wasting, stunting, and underweight).

The literature mentions that ambient (outdoor) and household (indoor) air pollution are environmental risk factors linked to several health conditions. These forms of air pollution were responsible for approximately 7 million deaths globally in 2016 (WHO, 2022). In 2016, ambient air pollution accounted for an estimated 4.2 million deaths due to stroke, heart disease, lung cancer, lower respiratory infections, and chronic obstructive pulmonary disease. Mortality rate is attributed to unsafe water, sanitation, or lack of hygiene. Malnutrition refers to deficiencies, excess, or imbalance in a person's energy and/or nutrient intake. It manifests in undernutrition (wasting, stunting, and underweight), deficiencies or excess micronutrients (vitamins or minerals), obesity, and associated diet-related NCDs.

### 5. Conclusion

This study examined the socioeconomic determinants and impacts of life expectancy in the Democratic Republic of the Congo using time series data from 1960-2020. Granger causality tests revealed that inflation, economic growth, population growth, and CO<sub>2</sub> emissions are significant drivers of life expectancy in the DRC. In turn, life expectancy Granger causes inflation, economic growth, mineral rents, and CO<sub>2</sub> emissions, suggesting complex bidirectional relationships. The negative impact of inflation on longevity and the resource curse are evident in the negative correlation between mineral rents and growth, which are notable findings. The positive effect of economic growth on life expectancy supports the predictions of human capital theory in the DRC context.

These results underscore the importance of government spending on health and education to promote longevity as a driver of economic development. Policies to control inflation, sustainably manage mineral wealth, and invest in human capital emerge as critical priorities. However, the study has limitations, including the restricted set of variables, short time series, and lack of granular subnational data. Expanding the analysis to a panel of African countries and investigating the mechanisms underlying the observed relationships are valuable areas for future work.

The findings highlight the complex interlinkages between demographic, health, and economic outcomes in developing countries. Understanding the levers and impacts of longevity is crucial for informing evidence-based policymaking to promote sustainable development. Continued research on the determinants of life expectancy employing rigorous quantitative methods is vital for designing effective interventions to improve both the quality and quantity of life.

## Declarations

### Ethics approval and consent to participate

Not applicable.

### Consent for publication

Not applicable.

### Availability of data and material

The data are available on request.

### Competing interests

The authors declare no conflict of interest or competing interests.

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