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Determinants of Life Expectancy over a Century in a Developing Country: The Case of Chile, 1900-2010

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Abstract
Although life expectancy is a key metric for assessing a population's health and well-being, there is a lack of both data and studies on this phenomenon over long periods of time in developing countries. Using original datasets for 1900-2010, this paper empirically measures the effect of certain determinants of life expectancy in Chile. The data considered includes sociodemographic information, measures of income distribution, and other indicators related to economic growth and the political system. The results show that, during the twentieth century, aspects related to certain sociodemographic variables, social inequality, and economic growth had a strong impact on the evolution of life expectancy in this country.

Keywords: Life expectancy, Chile, social inequality, economic growth, political system

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Introduction: Life expectancy in Chile in the twentieth century

In sociodemographic terms, life expectancy is a key variable for analyzing a society's development and progress. This variable is often considered as a relevant indicator to understand the effect of key policies on sustainable development (Miladinov 2020). In the case of Latin America, the topic has attracted great interest due to the historical prevalence of a social structure with high levels of inequality (Bilal et al. 2021). However, there is a lack of comparative empirical studies of the effect of sociodemographic, economic, and political factors on life expectancy. In Chile, life expectancy showed significant advances during much of the twentieth century and the first decade of the twenty-first century. Between 1920 and 1930, it increased from 31.8 years to 38 years and, in 1950, reached a historic figure compared to previous decades, averaging 54.3 years. Subsequently, it rose again significantly in the 1980s when it reached 69.1 years and, at the beginning of the 2000s, showed a constant, but smaller, increase (Díaz, Lüders and Wagner 2016).

Over the course of more than a century, this variable increased by nearly 40 years (from 32 years to 78.8 years), setting Chile apart from the rest of the region (see Table 1). Since the 1950s, only in Argentina, Costa Rica, Cuba, and Panama life expectancy has been on the rise at age 60, similar to developed countries, but different from the rest of the nations of the continent, where trends were significantly lower (Alvarez, Aburto, and Canudas-Romo 2020). In this context, this paper evaluates the factors that affected longevity in Chile during the twentieth century, with the aim of offering an insight on how government policies affect the lives of people in developing countries. The data considered includes population growth, measures of income distribution and other indicators related to economic growth as well as related to the evolution of the political system.

Table 1. Life expectancy at birth in Chile (1900-2010)

Year	Overall life expectancy at birth	Average rate of increase (%)
1900	32	0
1910	31.3	-2.2
1920	31.8	1.6
1930	38	19.5
1940	42	10.5
1950	54.3	29.3
1960	57	5.0
1970	62	8.8
1980	69.1	11.5
1990	73	5.6
2000	77.2	5.8
2010	78.8	2.1

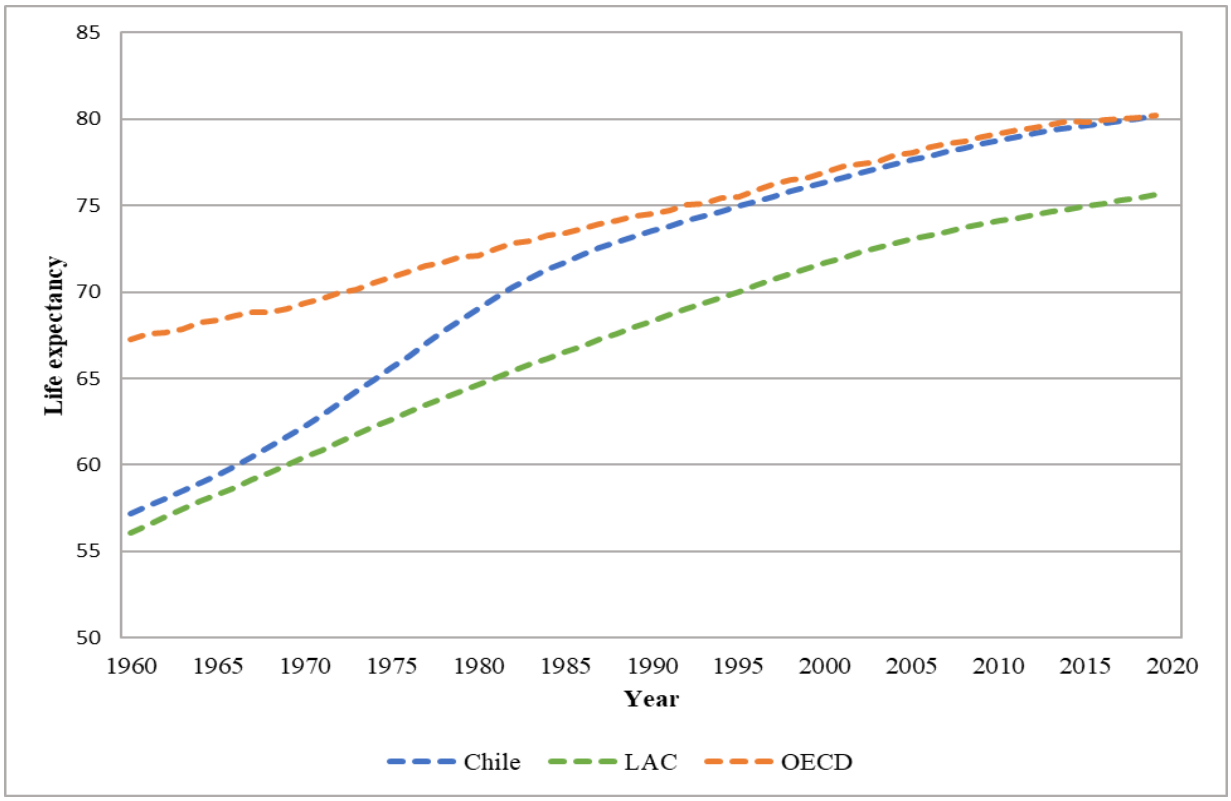
Source: Compiled by authors based on Díaz, Lüders and Wagner (2016).

In most countries of the world, life expectancy has grown steadily over time (Kabir 2008). However, as from the second half of the twentieth century, patterns of variability began to emerge

in different countries and geographical areas. This heterogeneity reflects factors associated with public policy decisions in specific areas of epidemiology and hygiene (Moser, Shkolnikov and Leon 2005; Soares 2007; Vågerö 2007). In the case of Latin America, studies have found that gains in life expectancy in developing countries such as Chile were the result of increased public health infrastructure, immunization policies, the adoption of medical technologies from developed countries, health education programs and public hygiene measures (Soares 2007). These measures produced significant improvements in the well-being of the population (Becker, Philipson and Soares 2005).

Life expectancy in Chile has generated interest because it is a developing country that has seen favorable results with respect to the Latin American and global context. In historical terms, when comparing the evolution of life expectancy in Chile with other Latin American and Caribbean countries, a gap is seen with respect to the regional average as from the second half of the 1960s, a trend that strengthened during the following decades. Since the second half of the 1970s, life expectancy in Chile has remained some four to five years above that in other countries in the region (see Figure 1).

Figure 1. Life expectancy at birth in years, 1960-2019



Source: Compiled by authors based on World Bank-World Development Indicators (2021a).
Note: Average life expectancy at birth in Latin America and Caribbean (LAC) and OECD countries.

Moreover, the evolution of life expectancy in Chile has not differed significantly from that in the member states of the OECD, an organization that groups together some of the world's largest and most developed economies. In 2010, when Chile officially joined the OECD, life expectancy at birth was 78.8 years compared to an OECD average of 79.1 years. Almost a decade later (2019), Chile had a life expectancy at birth of 80.6 years, ahead of countries such as Mexico, Colombia and even the United States, while the OECD average was 81 years (OECD 2021).

In this context, this research is based on the premise that, as a result of government policies, sociodemographic, economic and political factors have influenced the increase in life expectancy in Chile. Among the sociodemographic factors, there are important variables that depend on public policies such as infant mortality, population growth, illiteracy and the homicide rate while the economic factors include variables such as economic growth (GDP) and the Gini index and, in the case of the political factors, indicators of the type of political regime based on the Polity IV Project, which provides quantitative information about coding authority characteristics of states in the world system for purposes of comparative, quantitative analysis.

Historical Context in Chile

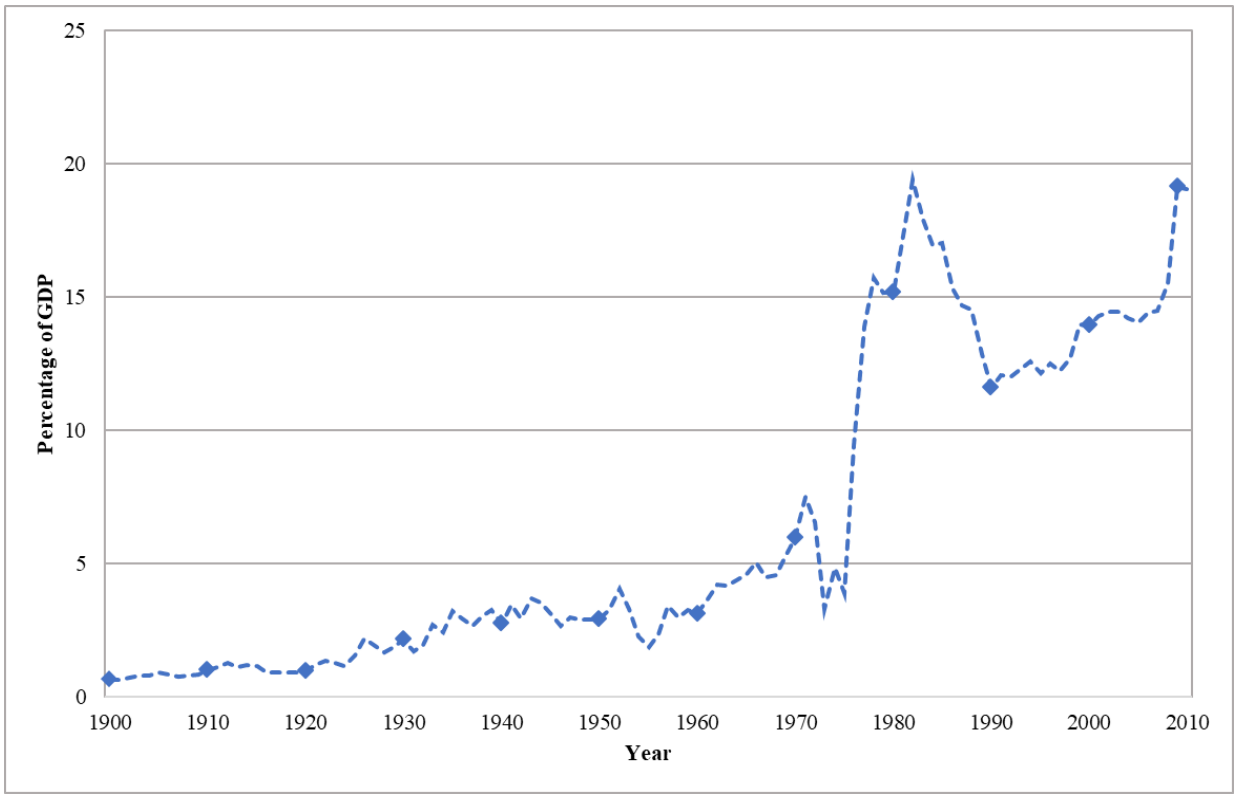
At the beginning of the twentieth century, Chile applied an *outward* growth strategy based on the export of raw materials and the import of manufactured products. Despite its initial advantages, this model left the country vulnerable to international economic crises. In the years after the First World War, the Chilean economy suffered the effects of a drop in overseas demand for saltpeter, a product on which practically all the country's tax structure depended. Revenues from saltpeter fell from about 110 million in 1918 to just over 40 million in 1921 and 1922. The crisis of the *outward* model reached its peak between 1929 and 1932, holding back national development (Pinto-Santa Cruz 2018).

However, during this period, the state was increasingly focusing on hygiene and public health, and this was reflected in the establishment of a number of specialized institutions. As from 1907, the Interior Ministry included a unit responsible for hygiene and public well-being and, in 1924, a Ministry of Hygiene, Public Assistance and Social Welfare was established, with a direct impact on sanitary conditions and control of mortality (Ibarra 2016). In 1924, the *Caja del Seguro Obrero* (Worker Insurance Organization) was also created. This semi-fiscal institution played a key role in the development of social security in Chile in the first half of the twentieth century because its income helped to finance the opening of new health care centers around the country (Goldsmith 2019). This set of health policy reforms was a direct result of the political environment. In 1927, President Carlos Ibáñez del Campo (1927-1931) reorganized government at the ministerial level and the Ministry of Hygiene, Public Assistance and Social Welfare was transformed into the Ministry of Social Welfare with responsibility for social areas such as public hygiene, social assistance, housing, workplace inspection and other urban services (Ibarra 2016).

Towards the mid-1930s, health policy was framed within an *inward* development strategy, marked by a statist vision and the promotion of national industry (Pinto-Santa Cruz 2018). In this context, under President Gabriel González Videla (1946-1952), the National Health Service was created in 1952. Subsequently, in 1954, the National Complementary Food Program (still in existence) was created, including a series of nutritional policies for the population such as the universal provision of milk for children up to six years of age and pregnant women (Goldsmith 2019). This institutional development created the conditions required for the implementation of a mass vaccination program that was one of the most important measures implemented by Chile during the first half of the twentieth century. Its greatest achievements included the eradication of smallpox in 1950, 27 years before the rest of the world, and the eradication of polio in 1975, 16 years before the rest of Latin America (González 2020).

Much of the progress in public health was possible thanks to the fiscal expansion seen as from the mid-1960s. However, despite the country's shift from a statist development model to a neoliberal model in the first half of the 1970s, following the installation of a military regime (Pinto Santa-Cruz 2018), the development of the state's social function continued and even intensified (Wagner, Jofré and Lüders 2000). As indicated by Larrañaga (1993), between 1974 and 1981 the military regime incremented significantly social spending as a result of a process of economic expansion based on privatizations and excessive levels of foreign debt. However, in 1982-1983 Chile witnessed a severe economic crisis after the suspension of external credits, a surge in unemployment, and a meltdown of the financial sector. This situation led to a reduction of central government social spending until 1990, when it started to increase again after democracy was restored (see Figure 2).

Figure 2. Central government social spending in Chile, 1900-2010 (percentage of GDP)



Source: Compiled by authors based on Díaz, Lüders, and Wagner (2016).
Note: Social spending includes health, housing, social security, education, employment and other social policy areas.

The country's vaccination policy was consolidated with the creation of the National Immunization Program in 1978. It facilitated systematization and administration of the vaccines that were already being applied, permitting wider national coverage and a focus on six of the main diseases affecting the child population (González 2020). The principles of compulsory, free and state-guaranteed vaccination were subsequently incorporated, defining public health as a state obligation, and ensuring its financing (Valenzuela 2001).

After the return to democracy in 1990, Chile experienced a period of political stability characterized by continuity of the neoliberal development model during and unprecedented economic growth. This brought significant improvements in wages, employment, and social services (Contreras and Ffrench-Davis 2012) and, as from this period, there was a renewed and sustained commitment to economic growth and increased social spending as the main tools for defeating poverty and redressing inequality. However, despite this progress, income inequality and the concentration of wealth in the elites remained high (Ffrench-Davis 2001; Garrido-Vergara 2020). This led to active debate in Chile about the role of income inequality in the country and its influence on the population's health (Subramanian et al. 2003).

In recent decades, Chile has stood out for a rapid rise in life expectancy compared to countries in Europe and North America (Palloni and McEniry 2007). This reflected the magnitude of the increase in the quality of life of the adult population (over 60 years) and a reduction of indicators associated with risk factors or chronic diseases such as smoking and obesity. In this context, although Chile obtained significant gains in its demographic indicators, due mainly to the implementation of improvements in health care, vaccination, and hygiene, it faces multiple challenges in continuing to raise life expectancy since, as studies of this phenomenon show at a global level, the higher this indicator, the more difficult it is to increase it (Bilal et al. 2021).

Although there are studies that substantiate the importance of sociodemographic, economic and political factors on life expectancy, they mostly focus on very limited periods of time. Therefore, this research contributes to reducing the gap in empirical studies in developing countries by incorporating long periods of time for the Chilean case.

The next section provides the literature review, while the following presents the data and techniques of analysis used. This are followed by description and discussion of the results and, finally, the conclusions.

Literature Review

Sociodemographic factors

There is empirical evidence of the importance of sociodemographic factors in the evolution of the population's life expectancy (Barlow and Vissandjée 1999; Florentino and Pedro 1992; Kakwani 1993; Potter 1991; Sachs, Mellinger and Gallup 2001; Schell et al. 2007; Schiff and Valdes 1990; Singh et al. 2017; Yavari and Mehrnoosh 2006). Life Tables, the analytic tool from which life expectancy is derived, are built from a set of age-specific death rates, including deaths during the first year of life (Preston et al., 2001; Xu et al. 2014). Even though social and economic policies typically are not necessarily focused on reducing mortality, they may affect survival. This study includes the infant mortality, as well as homicide rates, in the regression model to determine the contribution of these variables into overall growth of life expectancy considering three moments: short term (t-1), medium term (t-3) and long term (t-5).

Much of the progress achieved in reducing infant mortality was thanks to the development of public health in different countries around the world (Preston 1975, 1980, 1996). The boom in medical technology (Kramer 1980), changes in societal behavior and advances in medical treatment were key in prolonging the life of the infant population. This determined the development of society during the latter decades of the nineteenth century and throughout the twentieth century (Cutler, Deaton and Lleras-Muney 2006; Smith and Bradshaw 2006).

In Latin America, numerous efforts were made to reduce infant mortality as from the 1950s. However, given the prevalence of many forms of economic and political inequality and problems in accessing basic services, the results were mixed (Bähr and Wehrhahn 1993). It is nonetheless widely recognized that the sustained increase in life expectancy in the region was a consequence of the decrease in infant mortality, given the high number of infant deaths recorded during the first half of the twentieth century (Astorga, Bergés, and FitzGerald 2005).

Chile is one of the Latin American countries that has made the greatest progress in reducing infant mortality. At the beginning of the twentieth century, 342 children out of every 1,000 live births died before their first birthday (Díaz, Lüders and Wagner 2016). Beginning in the 1960s, Chile experienced a demographic and epidemiological transition, with direct effects on demographic indicators (Szot 2003). Between 1960 and 1990, the infant mortality rate for children under one year of age fell from 120 to 15.9 per 1,000 live births. By the twenty-first century, this indicator was below two digits, decreasing from 9.3 to 7.4 per 1,000 live births between 2000 and 2010 (see Table 2). In 2019, Chile had an under-one-year infant mortality rate of 6.5 per 1,000 live births (INE 2021). These figures differ significantly from those of other Latin American and Caribbean countries. In 2000, the regional under-one infant mortality rate, at an average of 27.5 per 1,000 live births, nearly tripled Chile's figure. By 2019, the indicator had dropped to 13.8 per 1,000 live births but remained almost twice as high as the figure for Chile (INE 2021; OECD/World Bank 2020). In comparison to other countries in Latin America, Chile's infant mortality rate is relatively low. Between 1980 and 2010, Chile registered the lowest infant mortality level with regard to the other countries in the continent (Garcia 2020).

Table 2. Sociodemographic, economic, and political indicators in Chile (1900-2010)

Year	IM		U		I		H		EC		GINI		SP		PR	
	R	AR	UP	AR	IR	AR	HR	AR	GDP	AR	GC	V(d)	SP %	AR	PI	ToR
1900	342	*0*	45	*7.1*	47.1	*0*	19.3	*48.5*	617,662	*13.3*	0.499	*-0.025*	0.6	*-45.6*	3	*Anocracy*
1910	267	*-21.9*	43	*-4.4*	49.7	*5.5*	18.8	*-2.6*	834,164	*35.1*	0.540	*0.041*	0.9	*50*	3	*Anocracy*
1920	263	*-1.5*	46	*6.9*	36.7	*-26.2*	27.2	*44.7*	780,999	*-6.4*	0.563	*0.023*	0.9	*0*	3	*Anocracy*
1930	234	*-11.0*	49	*6.5*	24.8	*-32.4*	11.4	*-58.1*	890,724	*14*	0.586	*0.023*	2.1	*133.3*	-2	*Anocracy*
1940	217	*-7.3*	53	*8.2*	26.7	*7.7*	15.6	*36.8*	966,683	*8.5*	0.572	*-0.014*	2.7	*28.6*	2	*Anocracy*
1950	136	*-37.3*	53	*0*	26.7	*0*	10.4	*-33.3*	1,099,342	*13.7*	0.523	*-0.049*	2.9	*7.4*	2	*Anocracy*
1960	120	*-11.8*	68	*28.3*	16.4	*-38.6*	4.9	*-52.9*	1,267,640	*15.3*	0.542	*0.019*	3.1	*6.9*	5	*Anocracy*
1970	79	*-34.2*	75	*10.3*	10.2	*-37.8*	6.1	*24.5*	1,531,941	*20.8*	0.487	*-0.055*	5.9	*90.3*	6	*Democracy*
1980	31.1	*-60.6*	75	*0*	10.2	*0*	1.7	*-72.1*	1,686,886	*10.1*	0.529	*0.042*	15.2	*157.6*	-7	*Autocracy*
1990	15.9	*-48.9*	82	*9.3*	8.3	*-18.6*	3.1	*82.4*	1,907,796	*13.1*	0.553	*0.024*	11.6	*-23.7*	8	*Democracy*
2000	9.3	*-41.5*	83	*1.2*	5.7	*-31.3*	5.2	*67.7*	3,026,747	*58.7*	0.534	*-0.019*	13.9	*19.8*	9	*Democracy*
2010	7.4	*-20.4*	87	*4.8*	2.5	*-56.1*	4.6	*-11.5*	3,929,219	*29.8*	0.543	*0.009*	19	*36.7*	10	*Democracy*

IM : Infant Mortality-- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016), INE (2021), and Kaempffer and Medina (2006)*.
R : Infant Mortality Rate (per 1,000 live births)
U : Urbanization -- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016)*.
UP : Urban Population (% of total population)
I : Illiteracy -- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016)*.
IR : Illiteracy Rate (% of people aged 15 and above)
H : Homicides -- *Source: Compiled by authors based on Rivero-Cantillano et al. (2022)*.
HR : Homicide rate (per 100,000 inhabitants)
EG : Economic Growth -- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016)*.
GDP : Real GDP per capita (in millions of CLP$ of 2003)
GINI : Gini Inequality Index -- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016)*.
GC : Gini Coefficient (0-1)
V(d) : Variation (decimal)
SP : Social Spending -- *Source: Compiled by authors based on Díaz, Lüders and Wagner (2016)*.
SP% : Social Spending (% of GDP)
PR : Political Regime -- *Source: Compiled by authors based on Marshall, Jaggers and Gurr (2015)*.
PI : Polity2 index (-10 to +10) -- *Note: Autocracy (-10 to -6); Anocracy (-5 to 5); Democracy (6 to 10)*.
AR : Average rate of increase (%)

In demographic terms, another important variable addressed in the literature is urbanization. Generally, people living in urban areas enjoy better medical care and better living conditions. In addition, they have better education and services with improved facilities that have a positive impact on the health of the population. This variable has played a crucial role in increasing life expectancy in developing countries (Kabir 2008).

Monsef and Mehrjardi (2015) empirically examined the link between life expectancy and economic, social, and environmental factors in 136 countries in 2002-2010. Their results show that the urban population, used as an indirect indicator of urbanization, had a significant impact on life expectancy. Similar results are found in other studies such as those of Shahbaz et al. (2016), who found that urbanization increased life expectancy in Pakistan in 1972-2012.

In Chile, the urban population steadily increased throughout the twentieth century and the beginning of the twenty-first century. In 1900, it accounted for 45% of the total population and it was only as from the 1940s that the percentage of the population living in urban areas (53%) exceeded the rural population. The figure showed a significant increase as from the 1960s and, by 2010, 87% of the population was urban (see Table 2).

One of the most important sociodemographic variables discussed in the literature is education. A number of studies have shown that education has a direct influence on the life expectancy of the population (Hazan 2011; Mackenbach et al. 2019). There is relative consensus that higher levels of education help people live longer compared to those with low levels of education and, particularly, those who are illiterate. In general, education enables people to become more aware of their health and take measures to care for it (Cutler, Deaton and Lleras-Muney 2006; Fayissa and Gutema 2005; Lutz and Kebede 2018).

Permanyer, Spijker, Blanes and Renteria (2018) analyzed the differences in life expectancy between different educational groups in Spain in 1960-2015. They found that life expectancy increased in all groups, but that the increase was largest in the more educated group. Similarly, research by Lin, Chen, Chien and Chan (2012) analyzed the influence of sociodemographic, economic and political factors on life expectancy between 1970 and 2004 in a sample of 119 countries. Their results demonstrate a positive relationship between the educational environment (literacy) and life expectancy. Studies by Bayati, Akbarian and Kavosi (2013) and Gilligan and Skrepnek (2015) found similar results when analyzing a sample of 21 Eastern Mediterranean countries, showing that literacy had a positive and significant association with life expectancy in 1995-2007 and 1995-2010, respectively.

In the case of Chile, the illiteracy rate declined significantly in the twentieth century (Sandoval and Turra 2015; Sandoval, Turra, and Luz 2022). In the early 1900s, it was running at 47.1% but began to decrease considerably in the 1930s. By 1990, it was already below 10% and, by 2010,

had dropped to a notable 2.5% (see Table 2). This marked an important difference with other Latin American and Caribbean countries. In 1990, the average illiteracy rate in the region was 15.6%, falling only modestly to 11% in 2000, and did not drop below 10% until 2005 (9.5%). In 2017, this indicator was 3.6% in Chile, while the average for the region was 6.3% (World Bank, 2021b).

Another important sociodemographic variable for analysis of life expectancy is the homicide rate. Violence has been one of the most significant public health problems in Latin America, a region that has one of the world's highest mortality rates (Briceño-León, Villaveces and Concha-Eastman 2008). Its level of complexity and effects on society have been of a magnitude such that it has even been considered an *epidemic* (Dávila-Cervantes and Pardo-Montaño 2018). This has had a negative impact on life expectancy. For example, Aburto and Beltrán-Sánchez (2019) showed that life expectancy for young men in Mexico has stagnated or dropped since 2005 due to the resurgence of violence and a rising homicide rate. Similarly, Dávila-Cervantes and Pardo-Montaño (2018) assert that the decline in homicide rates in Colombia after the 1990s benefited life expectancy for both men and women.

Latin American countries differ in the extent to which homicides have affected life expectancy. Canudas-Romo and Aburto (2019) demonstrate that homicides in Honduras, a country that has one of the region's highest homicide rates, caused a decrease in life expectancy for men and women compared to the average for European Union countries between 2010 and 2014. By contrast, homicides had a less significant impact on life expectancy in Chile, which has one of the region's lowest homicide rates.

The homicide rate in Chile behaved erratically in the first half of the twentieth century. According to Rivero-Cantillano et al. (2022), there were a total of 19.3 homicides per 100,000 inhabitants in 1900. In the 1910s and 1920s, the rate increased considerably, reaching 27.2 homicides per 100,000 inhabitants. Significant improvements then began to be seen as from the 1930s and, between 1950 and 1960, the rate dropped to below 10 homicides per 100,000 inhabitants. During the military dictatorship (1973-1989), there was a historic decline to just 1.7 deaths per 100,000 inhabitants between 1970 and 1980, partly due to the social repression and police control measures implemented by the Military Junta. After the restoration of democracy in 1990, small increases began to be seen and, in 2010, there were 4.6 homicides per 100,000 inhabitants (see Table 2).

In 2018, Chile had a rate of 4.4 homicides per 100,000 inhabitants while the average for the Americas (including Canada and the United States) was 16.5 (UNODC 2022). Although homicide figures in Chile are considered low compared to the rest of the region, excess mortality as a result of homicides has been and continues to be a crucial challenge for increasing longevity in the region (Canudas-Romo and Aburto 2019).

Economic factors

The literature has emphasized that income measured as gross domestic product (GDP) is one of the key determinants of life expectancy (Anand and Ravallion 1993; Pritchett and Summers 1996; Rodgers 1979; Wilkinson 1997). Studies by different authors (Cutler, Deaton and Lleras-Muney 2006; Gilligan and Skrepnek 2015; Lin, Chen, Chien and Chan 2012; Marmot 2005; Monsef and Mehrjardi 2015) show that higher economic growth expressed in an increase in GDP has been positively associated with a significant increase in life expectancy.

For example, Mackenbach and Looman (2013) analyzed the role of national income in changes in life expectancy for a group of European countries between 1900 and 2008. Their results show that economic growth had positive effects on life expectancy, underlining the importance of national income for the health of the population. Research by Delavari et al. (2016) produced similar results, showing that the level of economic development had a positive influence in Iran between 1985 and 2013. Ebenstein et al. (2015) found evidence that the gradual increase in life expectancy in China has been a consequence of this country's unprecedented economic growth since the early 1990s.

However, there are studies that offer different perspectives on the relationship between income and life expectancy, suggesting that it is not as linear as it seems. For example, Caldwell's seminal work (1986) analyzed the evolution of mortality in poor countries around the world. Part of his findings showed that its decrease was closely correlated with improvements in education, health, family planning and food subsidies for the poor. In this sense, economic growth is important to the extent that a larger share of the budget is invested in social areas such as education and health. Otherwise, there does not appear to be a direct relationship between economic growth and life expectancy. In addition, Soares (2007) shows that increases in life expectancy in developing countries between 1960 and 2000 were largely independent of improvements in income. In this sense, public health infrastructure, immunization, specific social programs and the dissemination of new forms of knowledge seem to have been more important factors.

Life expectancy in developing countries continued to rise in the twentieth century despite continued political instability and economic crises. Indeed, the long-term history of Latin America and the Caribbean is often regarded as one of progress. Even in those countries where economic growth was weak, there were significant improvements in health between 1960 and 2000 (Soares 2009). In this context, the Chilean economy has positioned itself as one of the most successful in Latin America and the Caribbean, achieving important advances in the different areas of social and economic policy, which have led many to view it as a reference for the rest of the region (Mainwaring and Bizarro 2019).

Many of these results began to be seen in the 1990s when the economic success of the democratic governments was able to counteract the effects of fiscal policy and control of inflation in the 1980s

(Ffrench-Davis 2016). This was reflected in a sustained increase in GDP per capita, which peaked in the 2000s, with 58.7% growth compared to the 1990s (see Table 2). Despite the expansion of the Chilean economy, the social context was dominated by high levels of socioeconomic inequality (Ffrench-Davis 2001) and its impact on life expectancy has been a matter of debate. Traditionally, the income gap between a country's different social sectors has been considered a solid explanation for many of the differences in life expectancy (Geruso 2012).

The health of those with very low incomes is much more likely to be compromised by poor nutrition, poor sanitation, and limited access to health services. Conversely, people with higher incomes are more likely to have access to adequate infrastructure and better health services. What is interesting about this point is that, in many countries, access to better health services was the result of economic progress and GDP growth over time (Gilligan and Skrepnek 2015).

Socioeconomic inequality in a country is analyzed using the Gini index, which shows how equitably income is distributed among the population and illustrates how equity has changed over time (Farris 2010). In this context, the literature has discussed the effect of income inequality on life expectancy (Bor, Cohen and Galea 2017; Thumala et al. 2017). Some authors take the view that social and health problems tend to worsen when income inequality is high (Wilkinson and Pickett 2009) while others consider there is insufficient evidence to affirm that income inequality is a determinant of health differences in the population, particularly in the case of wealthy countries (Lynch et al. 2004). However, some studies support the importance of this variable in relation to life expectancy. For example, in a study covering 54 countries, Rochelle et al. (2014) showed that income inequality, measured using the Gini coefficient, has been negatively correlated with men's life expectancy. This is consistent with the work of Messias (2003), who found a negative association between life expectancy and income inequality in different Brazilian states.

The Gini inequality index in Chile showed little change during much of the twentieth century. In 1900, Chile had an index of 0.499, a figure that showed constant fluctuations in the following decades. It was at its lowest in the early 1970s (0.487). After the restoration of democracy, under the economic model inherited from the military dictatorship, it showed a trend similar to that seen in the first half of the twentieth century. Indeed, between 2000 and 2010, it increased from 0.534 to 0.543 (see Table 2). In 2017, Chile had a Gini coefficient of 0.454 while, in 2018, the figure for 15 Latin American and Caribbean countries was 0.465. Despite advances in the region, inequality has been characterized by its multifaceted, structural nature and persistence over time (ECLAC 2019). In the case of Chile, socioeconomic inequality has become an important problem with direct effects on the health of the population (Moreno, Lera, Moreno and Albala 2021).

In an interesting aspect of this phenomenon, the relationship between income inequality and life expectancy may be more complex than it currently appears. According to a study by Edwards, Soto and Zurita (2021), there is a three-year difference in life expectancy in Chile between the

lower and higher-income groups who retired under the annuity system. However, this may suggest a relationship of mutual causality between life expectancy and income inequality, at least in recent years, since the increased longevity of the population has posed new challenges for the pension system implemented in 1981.

Lastly, government social spending is another variable considered to have a direct influence on life expectancy. Traditionally, investment in education and health has contributed to gains in life expectancy. Social policies can, therefore, be an important way to improve the health of the population (Reynolds and Avendano 2018). However, some authors have suggested that the relationship is not necessarily so direct. For example, Kabir (2008) argued that increases in GDP per capita, population planning measures, access to safe drinking water and high public spending on education and health are important factors for well-being and social development, but do not necessarily guarantee increases in life expectancy in developing countries.

In Chile, social spending as a percentage of GDP was modest in the early decades of the twentieth century. In 1900, it represented 0.6% of GDP and, as from 1930, reached just over 2% (2.1%). It is interesting to note that, as from the 1980s, this variable showed an exponential increase (15.2%), coinciding with the 1973-1990 military dictatorship. Social spending as a percentage of GDP peaked in 2010 at 19% of GDP (see Table 2).

Political factors

The literature has shown that the political regime is a factor that helps explain changes in life expectancy (Franco, Álvarez-Dardet and Ruiz 2004; Kabir 2008; Kawachi et al. 1999; Navarro and Shi 2001; Shen and Williamson 1997). As a way to operationalize this factor, some authors have analyzed the effect of democracy on the population's health and social well-being (Lake and Baum 2001; Navarro et al. 2006).

Research by Franco, Álvarez-Dardet, and Ruiz (2004) shows that democracy has a strong and significant association with health indicators such as life expectancy and infant mortality. Navarro et al. (2006) argued that political parties in democratic contexts have been more inclined to promote redistribution policies focused on social assistance and public spending on health. This correlation is particularly evident in OECD countries, which have had sustained periods of democratic government led by social democratic parties. By contrast, countries that have had prolonged periods of dictatorship tend to have very low percentages of direct transfers and few income distribution policies, with obvious consequences for the health of the population.

It has generally been assumed that a more democratic country can guarantee citizens' rights and produce public services geared to social needs (Gerring, Bond, Barndt and Moreno 2005; Swiss, Fallon and Burgos 2012). The public policies implemented by these governments are important in improving the health and living standards of the population since they regulate labor markets and

allocate higher percentages of the budget to public health (Lake and Baum, 2001; Navarro et al. 2006).

Public policies facilitate the redistribution of resources to those who need them most (Flegg 1982; Ruger and Kim 2006). The effectiveness of the political regime is, therefore, important for the proper functioning of health systems (Cutler, Deaton and Lleras-Muney 2006) and the formulation of social policies (Marmot 2005; Monsef and Mehrjardi 2015).

In Chile, democracy showed important advances during much of the twentieth century. Historically, the country's institutional framework has evolved in a way similar to that of some institutions in Europe and the United States, enabling it to resolve situations that were generally considered harmful to the consolidation of democracy over time (Valenzuela and Valenzuela 1983). After setbacks, mainly during the military dictatorship (1973-1989), the democratic transition of the 1990s led to the establishment of stable governments with guarantees of social peace (Carruthers 2001). This was possible in part thanks to the pact formed between the political-party elites through two coalitions that ensured electoral competition and governed between 1990 and 2010 (Garrido-Vergara 2020). As a result, Chile has been regarded as a Latin American country with a high-quality democracy (Mainwaring and Pérez-Liñán 2015; Pérez-Liñán and Mainwaring 2013), which evolved from an "anocracy" in 1900 to a "democracy" in 2010 (see Table 2).

Based on the factors discussed in this research, eight general hypotheses are proposed: (*H1*) An increase in the infant mortality rate negatively affects life expectancy in the short term; (*H2*) An increase in the level of urbanization positively affects life expectancy in the short term; (*H3*) An increase in illiteracy rates negatively affects life expectancy in the long term; (*H4*) An increase in homicide rates negatively affects life expectancy in the long term; (*H5*) An increase in economic growth positively affects life expectancy in the long term; (*H6*) An increase in the Gini index negatively affects life expectancy in the long term; (*H7*) An increase in social spending positively affects life expectancy in the long term; and (*H8*) An increase in the quality of the political regime positively affects life expectancy in the long term. A summary of the relevant factors, their operationalization and their respective hypotheses are shown in Table 3.

Table 3. Factors affecting life expectancy in Chile (1900-2010), operationalization and hypotheses

Factor	Operationalization	Hypothesis
Sociodem Sociodemographic	Infant mortality (Infant mortality rate per 1,000 live births)	H_1. An increase in the infant mortality rate negatively affects life expectancy in the short term.
	Urbanization (Urban population as a percentage of the total population)	H_2. An increase in the level of urbanization positively affects life expectancy in the short term.
	Illiteracy (Illiteracy rate for people aged 15 and above)	H_3. An increase in illiteracy rates negatively affects life expectancy in the long term.
	Homicides (Homicide rate per 100,000 inhabitants)	H_4. An increase in homicide rates negatively affects life expectancy in the long term.
Economic	Economic growth (GDP) (logarithm of per capita GDP in 2003 pesos)	H_5. An increase in economic growth positively affects life expectancy in the long term.
	Gini coefficient (Ranges from 0 to 1)	H_6. An increase in the Gini index negatively affects life expectancy in the long term.
	Social spending (Percentage of GDP)	H_7. An increase in social spending positively affects life expectancy in the long term.
Political	Polity2 is a revised combined POLITY Score from the Polity IV project (Marshall, Jaggers and Gurr 2015). This variable is a modified version of the POLITY variable added to facilitate the use of the POLITY regime measure in time-series analyses. It modifies the combined annual POLITY score through a simple treatment to convert instances of "standardized authority scores" (i.e. -66, -77, and -88) to conventional polity scores (i.e. within the range of -10 to +10)	H_8. An increase in the quality of the political system positively affects life expectancy in the long term.

Source: Compiled by the authors.
Note: The way to operationalize the short (*t-1*), medium (*t-3*) and long (*t-5*) term is adjusted to the times considered in the analysis, where *t-1* corresponds to one year, *t-3* to three years and *t-5* to five years of calendar difference.

Data and techniques of analysis

To measure the effect of the relevant factors on life expectancy in Chile, data was gathered from different sources. First, time series data on economic and social dimensions for 1910-2010, drawn from the work of Díaz, Lüders and Wagner (2016), was incorporated. These authors constructed continuous and homogeneous series of indicators grouped into the following areas: production; internal absorption; fiscal accounts; unit of account, prices and exchange rate; international trade; monetary and financial resources; and people. The statistical information comes mainly from the National Institute of Statistics (INE), the Central Bank, the Ministry of Finance and the Corporation for the Promotion of Production (CORFO). It also includes methodologies and reconstructions from other authors. As indicated in the book, the sources considered by the authors to estimate life expectancy in Chile during the twentieth century are based on both State and Non-State sources (p. 59). In this case, the data source is *Gapminder* (http://gapm.io/ilex).

Secondly, given the importance of homicides as a key measure of well-being, data was obtained from research by Rivero-Cantillano et al. (2022) and Rivero-Cantillano and Llorca-Jana (2022) who compiled the number and rates of homicides in Chile throughout the twentieth and twenty-first centuries (from data obtained from the Civil Registry and Identification Service and Official Demographic Yearbooks of Chile). In particular, data for 1900-2010 was used. Regarding the quality of the data, statistical series were constructed based on the statistical yearbooks available from the INE and the National Library. Causes of death per year were taken from the Civil Registry and were then classified into the groups of diseases established by the World Health Organization (WHO) (homicides correspond to "external causes").

Thirdly, the Polity2 Index variable was used to measure the political regime in Chile in 1900-2010. This variable belongs to the dataset of the Polity IV project of 2013, which has been used in different research projects (see Mackenbach, Hu and Looman 2013; Pieters, Curzi, Olper and Swinnen 2016). Regarding the quality of the data, this was compiled from the central statistical agencies, applying methodologies of historical reconstructions and estimates by the authors (Marshall, Jaggers and Gurr 2015). A summary of the measurement and the methodology applied in defining the variables can be found in Appendices 1, 2, 3, and 4.

This study explores and analyzes time series data using multiple linear regression models to study the effect of the sociodemographic, economic and political determinants of life expectancy in Chile over the course of the twentieth century and in the early twenty-first century. The analysis is correlational and exploratory, considering both the longitudinal nature of the data for the period between 1990 and 2010 and the possibility of finding confounding factors or reverse causalities (Dominici, McDermott, Zeger and Samet 2002). In the log-linear model, the dependent variable is a product, rather than a sum, of independent variables (von Eye, Mun and Mair 2012). The main purpose of this analysis is to measure the effect of the variation of a set of independent variables on the variation in life expectancy during the period studied.

To address possible difficulties concerning reverse causalities, the analysis used lagged realizations of the independent variables at different times considering three moments: one year (*t-1*), three years (*t-3*) and five years (*t-5*) before the current time (t) to test their effect on life expectancy, considering the hypotheses shown in Table 3. Each year corresponds to twelve months. These periods were selected based on the average length of presidential terms in the twentieth century. This is important since, barring the occurrence of a catastrophic event, it is highly likely that social, demographic, political and economic changes will affect the human lifespan in a subsequent, rather than the same, period (Permanyer and Scholl 2019). The following equations were estimated:

Equation 1:

$$(Life\_Expectancy)_t = \beta_0 + \beta_1 In\_M\_R_{(t-1)} + \beta_2 P\_Urban_{(t-1)} + \beta_3 Illiteracy_{(t-1)} +$$

$$\beta_4 SE\_GDP_{(t-1)} + \beta_5 HOM_{(t-1)} + \beta_6 GINI_{(t-1)} + \beta_7 Polity2_{(t-1)} + \beta_8 logGDP\_{\sim}2003_{(t-1)} + \varepsilon_t$$

Equation 1 includes the independent variables and life expectancy, where the latter is expected to depend on the other variables (covariates) at time *t-1*. In this specification, life expectancy was used so that each coefficient can be interpreted as the approximate percentage change in life expectancy associated with a one-unit increase in the independent variable of interest.

The independent variables are indicated in Table 3 and were selected based on a review of the literature and the definition of the hypotheses in the following order: infant mortality rate, urban population (as a percentage of total population), level of illiteracy (expressed as a percentage of the total population), social spending (as a percentage of GDP), homicide rate per 100,000 inhabitants, Gini coefficient, Polity2 index, which measures the level of democracy (between -10 and 10, where -10 is autocratic and 10 is fully democratic), and the natural logarithm of GDP per capita (in millions of CLP$ of 2003). Ordinary least squares (OLS) were used to estimate the linear coefficients β_1 to β_8 and the constant term β_0. The term ε_t corresponds to the unobserved stochastic component and standard errors for each estimate are robust to heteroscedasticity. Since this analysis uses lagged realizations of the independent variables at different times (*t-1, t-3,* and *t-5*) to avoid reverse causality, a second equation was estimated including the determinants at three different moments:

Equation 2

$$(Life\_Expectancy)_t = \alpha + \boldsymbol{\beta}' Determinants_{(t-1)} + \boldsymbol{\gamma}' Determinants_{(t-3)} + \boldsymbol{\delta}' Determinants_{(t-5)} + \eta_t$$

In equation 2, β, γ, and δ are parameter vectors corresponding to the first, third and fifth lags of these measures, respectively. Ordinary least squares (OLS) models were used to estimate the linear

coefficients β_1 to β_8 and the constant term β_0. The term η_t corresponds to the unobserved stochastic component and standard errors for each estimate are robust to heteroscedasticity. The corresponding multicollinearity tests were performed using the VIF method for each independent variable. No collinearity problems were detected in any of the cases.

Based on these two equations, four OLS models were developed to measure the effects of the independent variables on life expectancy, including the first, third and fifth lags of these measures. As shown in Table 4, the models included the following independent variables in order to measure their effect on life expectancy: a model with the independent variables at moment *t-1*, a second model with the independent variables at moment *t-3,* a third model with the independent variables at moment *t-5*, and a fourth model with the independent variables at moments *t-1*, *t-3,* and *t-5*. The models were defined considering descriptive analyses in the relationship between the dependent variable and the independent variables taking as reference the four moments: *t-1, t-3,* and *t-5* (see Appendices 3 and 4).

Although this is an unprecedented study for a Latin American country such as Chile, it has some limitations that are determined by the quality of the data and the statistical model used. First, the research is based on population-level indicators including 111 cases (1900 to 2010). Although this could be considered as a small number of observations for predictive analysis, it is important to note that multiple linear regression is appropriate for the data used. Given that the data is presented for each year of the study, it is relevant to examine the relationships between the independent variables and the evolution of life expectancy. Secondly, given the difficulties in obtaining high-quality information for the variables relevant to the case of Chile, the data was obtained from previous work that has systematized the statistical information corresponding to the twentieth century in Chile (Díaz, Lüders and Wagner 2016; Rivero-Cantillano et al. 2022). This is duly justified in the methodological sections (see Appendices 1 and 2).

Thirdly, in light of the complexities of operationalizing the different types of political regime, it was decided to use the data of a project that studies democracy in Latin America and globally (Marshall, Jaggers and Gurr 2015), which has been extensively validated in other academic research (Mackenbach, Hu and Looman 2013; Pieters, Curzi, Olper, and Swinnen 2016). These limitations were key in determining the techniques used in consideration of the data's analytical potential.

Results and discussion

The results observed in the OLS models shown in Table 4 and Figures 3, 4, 5, and 6 provide interesting evidence for analyzing the effects of the sociodemographic, economic, and political determinants of life expectancy in Chile between 1900 and 2010. This data indicates that the effects vary depending on the variables included in the different models. The goodness of fit is generally quite high, even when the values of the Akaike information criterion tend to be similar.

Model four is of better statistical quality in terms of the relationship of the goodness of fit and the complexity of the models. In the case of the Bayesian information criterion, which allows us to identify the level of fit according to the explanatory variables, Model 3 is also significant.

Table 4. Correlational evidence on long trends in life expectancy in Chile, 1900-2010

Model		IM	U	I	H	SP	GINI	EG	PR	_cons	N	R-sq	adj. R-sq	AIC	BIC
1	***(t-1)***	-0.0598***	0.266**	-0.149**	-0.151**	0.359**	-43.55***	1.963	0.157*	43.60	110	0.985	0.984	493.0	517.3
		(0.000)	(0.000)	(0.002)	(0.006)	(0.003)	(0.000)	(0.222)	(0.034)	(0.084)					
2	***(t-3)***	-0.0506***	0.129	-0.245***	-0.197***	0.453***	-55.30***	4.309*	0.0893	27.20	108	0.983	0.982	497.2	521.3
		(0.000)	(0.186)	(0.000)	(0.001)	(0.001)	(0.000)	(0.015)	(0.254)	(0.319)					
3	***(t-5)***	-0.0537***	0.0167	-0.312***	-0.180**	0.435**	-66.67***	5.871**	0.0274	21.42	106	0.983	0.981	489.1	513.1
		(0.000)	(0.865)	(0.000)	(0.002)	(0.001)	(0.000)	(0.002)	(0.727)	(0.457)					
4	***(t-1)***	-0.0529***	-0.0564	-0.0390	-0.0309	0.0391	146.3	0.208	0.330***						
		(0.000)	(0.689)	(0.702)	(0.571)	(0.799)	(0.133)	(0.938)	(0.000)	87.88*	106	0.992	0.989	442.6	509.2
	(t-3)	-0.000249	-0.0225	-0.0827	-0.148**	0.314	-254.4	-1.976	0.0237	(0.035)					
		(0.987)	(0.878)	(0.452)	(0.008)	(0.093)	(0.131)	(0.399)	(0.829)						
	(t-5)	-0.0222	0.0160	-0.182	-0.0980	0.198	55.82	2.827	-0.00725						
		(0.118)	(0.893)	(0.067)	(0.144)	(0.192)	(0.520)	(0.177)	(0.948)						

IM : Infant Mortality
U : Urbanization
I : Illiteracy
H : Homicides
SP : Social Spending
GINI : Gini Inequality Index
EG : Economic Growth
PR : Political Regime
--

Standard errors in parentheses

$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Source: Compiled by the authors.
Note: For much of the twentieth century, Chile's presidential term lasted six years. After the end of the military dictatorship in 1990, there was a four-year government and two six-year governments until 2005, when the current four-year term of office was established. On average, the presidential term during the twentieth century and the first decade of the twenty-first century was about five years. Model 3 (*t-5)* reflects this trend.

The four models allow us to analyze the effects of the determinants on life expectancy at three moments: the short term (*t-1*), the medium term (*t-3*) and the long term (*t-5*). In the case of Model 1 (*t-1*), four variables have negative effects on life expectancy. The Gini coefficient has the greatest effect and significance (β= -43.55) and the illiteracy (β= -0.149) and homicide rates (β= -0.151) also have a significant negative effect, but of lesser magnitude than the Gini coefficient, while the infant mortality (β= -0.0598) also has a negative effect but of smaller magnitude than the previous three variables. In addition, there are three variables with significant positive effects on life expectancy. The social spending as a percentage of GDP has the greatest significance and magnitude (β=0.359). It is followed by urban population (β=0.266) and the type of political regime (β=0.157), both of which have effects of a similar magnitude. Lastly, in Model 1, the variable corresponding to the logarithm of per capita economic growth does not have significant effect on the variation in life expectancy.

In the case of Model 2 (*t-3*), the infant mortality rate continues to have a significant negative effect on life expectancy, but with a magnitude slightly lower than the previous value (β=-0.0506). Both illiteracy and homicide rates maintain a high level of significance and, importantly, the magnitude of the effect continues to increase (β=-0.245; β=-0.197), indicating a negative effect that grows in the medium term. Finally, the Gini coefficient remains the variable with the greatest effect and significance (β=-55.30). In the case of the variables with significant positive effects on life expectancy, social spending as a percentage of GDP maintains a high significance (β=0.453). In this model, the variable corresponding to the logarithm of per capita GDP has a slightly significant effect but of great magnitude on life expectancy (β=4.309).

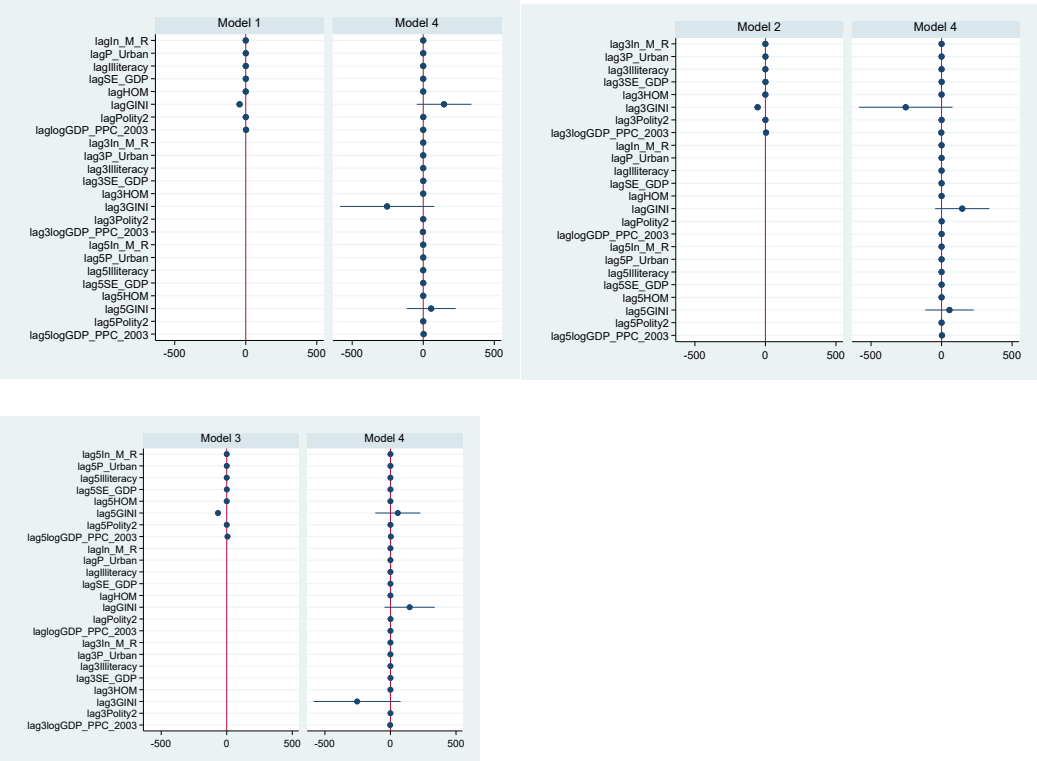
In Model 3 (*t-5*), trends are similar to those seen in the other models, but with interesting variations. First, the Gini coefficient has an effect of greater magnitude and is highly significant (β=-66.67). The illiteracy rate increases its magnitude and significance in relation to previous periods (β=-0.312) while the homicide and infant mortality rates continue to have significant effects, but of smaller magnitudes (β=-0.180; β=-0.053). As in Model 2 (*t-3*), social spending as a percentage of GDP also maintains a significant effect, but of a smaller magnitude. Interestingly, in the case of the logarithm of per capita economic growth (β=5.871), both the magnitude and its significance increase, indicating that this variable has a medium to long-term effect on life expectancy. This is consistent with the literature analyzed on the effects of economic growth on the health of the population (Collier and Sater, 1998; Ffrench-Davis 2001; Gilligan and Skrepnek 2015; Sickles and Taubman 1997).

Model 4 was included to group together all the periods considered in the previous models (*t-1, t-3,* and *t-5*). In this model, only the infant mortality rate maintains a significant negative effect on life expectancy at time t-1 (β=-0.0529) while the type of political regime maintains a significant positive effect at time t-1 (β=0.330). This empirically reaffirms the findings reported in the literature on Chile and developing countries (Mondal and Shitan 2014). During much of the

twentieth century, Chile experienced complex political processes, with a prevalence of poverty, illiteracy and growth problems that persisted until the end of the 1980s and certainly had negative effects on life expectancy (Collier and Sater 1998).

Concerning predictive margins analysis with variables at time t-1, t-3, and t-5, with a 95 percent level of confidence, (see Figures 4, 5, and 6) in the case of the Gini coefficient, the results show that a lower value of the Gini coefficient increases the probability of longevity. The increase in inequality from 0.499 in 1900 to 0.543 in 2010 is responsible for decreasing life expectancy by 2 years when t-1 and t-3. However, when t-5, Gini is responsible for decreasing life expectancy by 4 years. Something similar happens with illiteracy and homicides. In the case of illiteracy, it decreased from 47.1 in 1900 to 2.5 in 2010, which increased life expectancy by 7 years when t-1, 11 years when t-3, and 14 years when t-5. The homicide rate decreased from 19.3 in 1900 to 4.6 in 2010, which is responsible for incrementing life expectancy by 2 years when t-1, and 3 years when t-3, and t-5.

Figure 3. Effects of sociodemographic, economic, and political determinants on life expectancy in Chile



Source: Compiled by the authors.

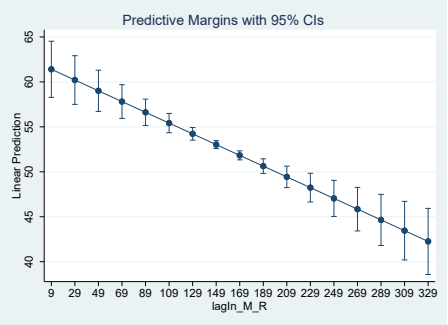
In the case of the social spending as a percentage of GDP, the results show that a bigger value of this variable increases the probability of living more years. The increase of social spending as a percentage of GDP from 0.6 in 1900 to 19 in 2010 is responsible for increasing life expectancy by

7 years when t-1, and 8 years when t-3 and t-5. In the case of per capita economic growth, its increase from 617.662 in 1900 to 3.929.219 (millions of CLP$ of 2003) in 2010 contributed to increase life expectancy by 11 years when t-3 and t-5. Something similar happened with political regime (1 year when t-1 and t-3) and urbanization (1 year when t-1 and t-3). In the case of homicides and economic growth the confidence interval tends to be much wider than the other variables. Finally, the decrease in infant mortality from 342 in 1900 to 7.4 in 2010, is responsible for life expectancy increase by nearly 22 years when t-1, and 16 years when t-3 and t-5. These results illustrate the importance of policies to reduce social inequities and against social violence in order to increase life expectancy, and empirically contribute the findings of previous studies of the evolution of life expectancy in Chile and Latin America (Mondal and Shitan 2014).

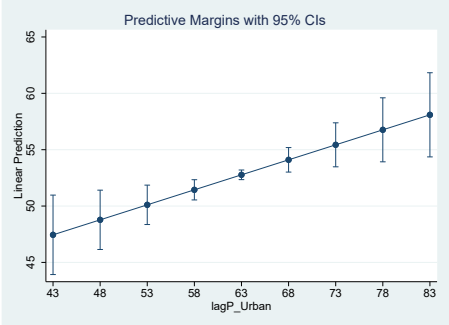
Lastly, regarding the testing of the hypotheses, our quantitative analysis provides empirical evidence to corroborate Hypothesis 1, since the infant mortality rate has significant negative effects on life expectancy of an important magnitude in the short term. However, it is important to note that this variable has relevant effects in all periods. Hypothesis 2 is also supported since the percentage of urban population influences life expectancy in the short term. Hypothesis 3 is supported as well, given that increased illiteracy has a significant long-term effect on life expectancy. In addition, Hypothesis 4 is supported since the models indicate that the homicide rate has long-term effects on life expectancy. This is also true for Hypothesis 6 and Hypothesis 7 since both the Gini index and social spending have a long-term effect. Finally, the political regime has a short and medium-term effect, failing to contradict Hypothesis 8. These results support the interpretation that, in the Chilean case, government policies developed throughout twentieth century had a positive effect on the lives of people, which is remarkable when comparing Chile to the average of Latin American developing countries, as indicated in Figure 1.

Figure 4. Probability of longevity (t-1)

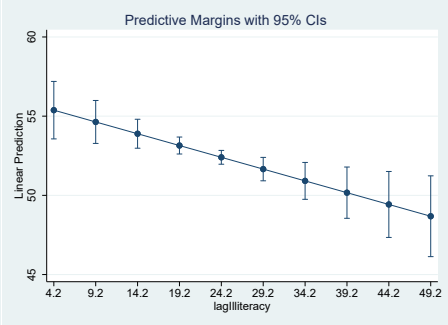
Infant Mortality (*lagIn_M_R*)



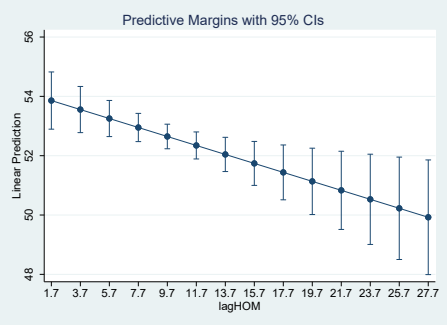
Urbanization (*lagP_Urban*)



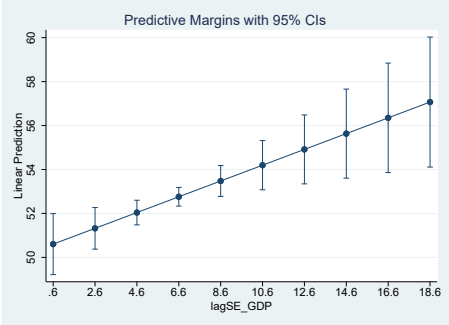
Illiteracy (*lagIlliteracy*)



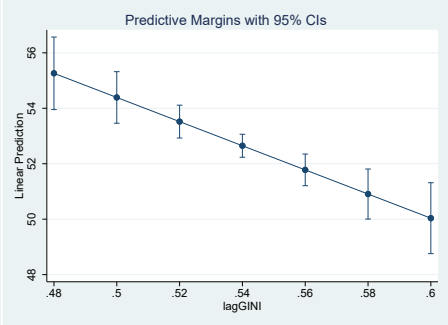
Homicides (*lagHOM)*



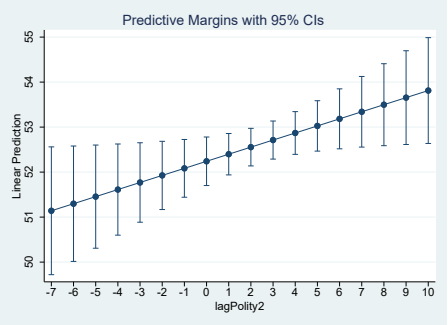
Social Spending (*lagSE_GDP*)



Gini (*lagGINI*)

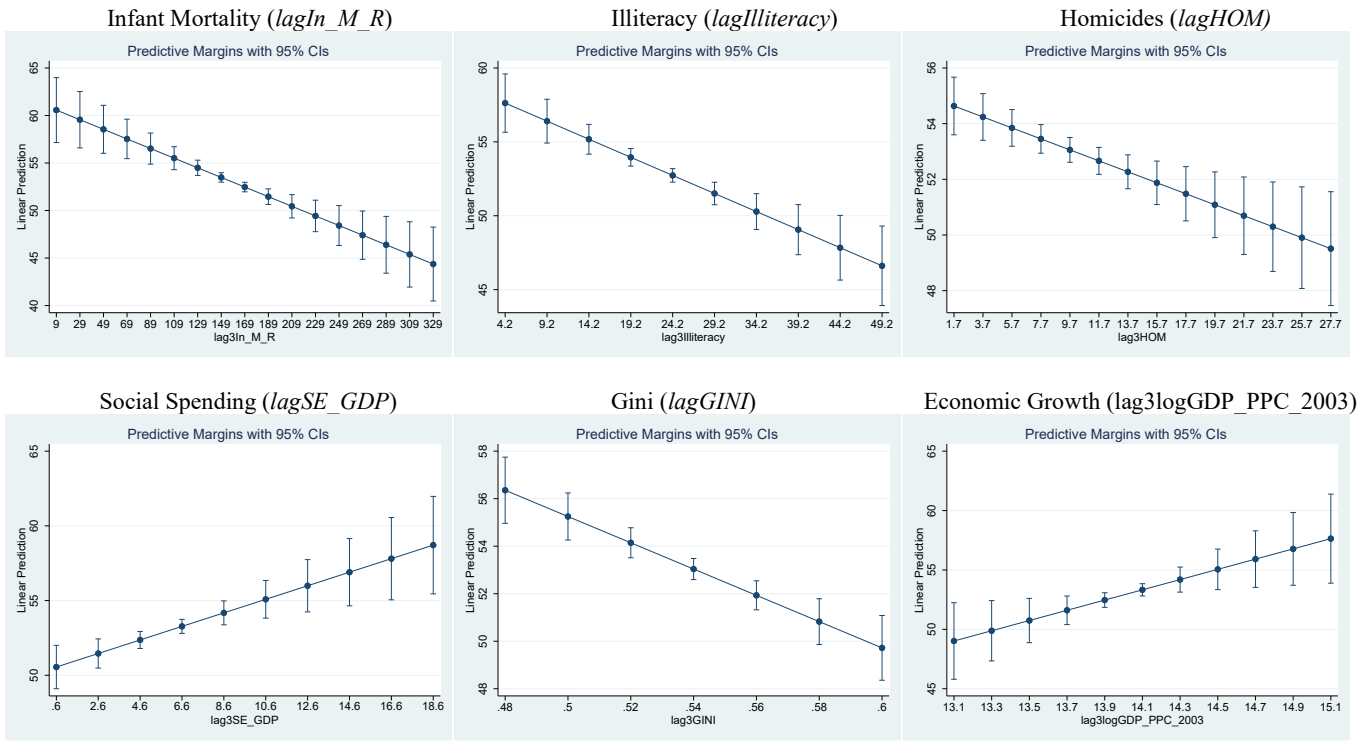


Political Regime (*lagPolity2*)



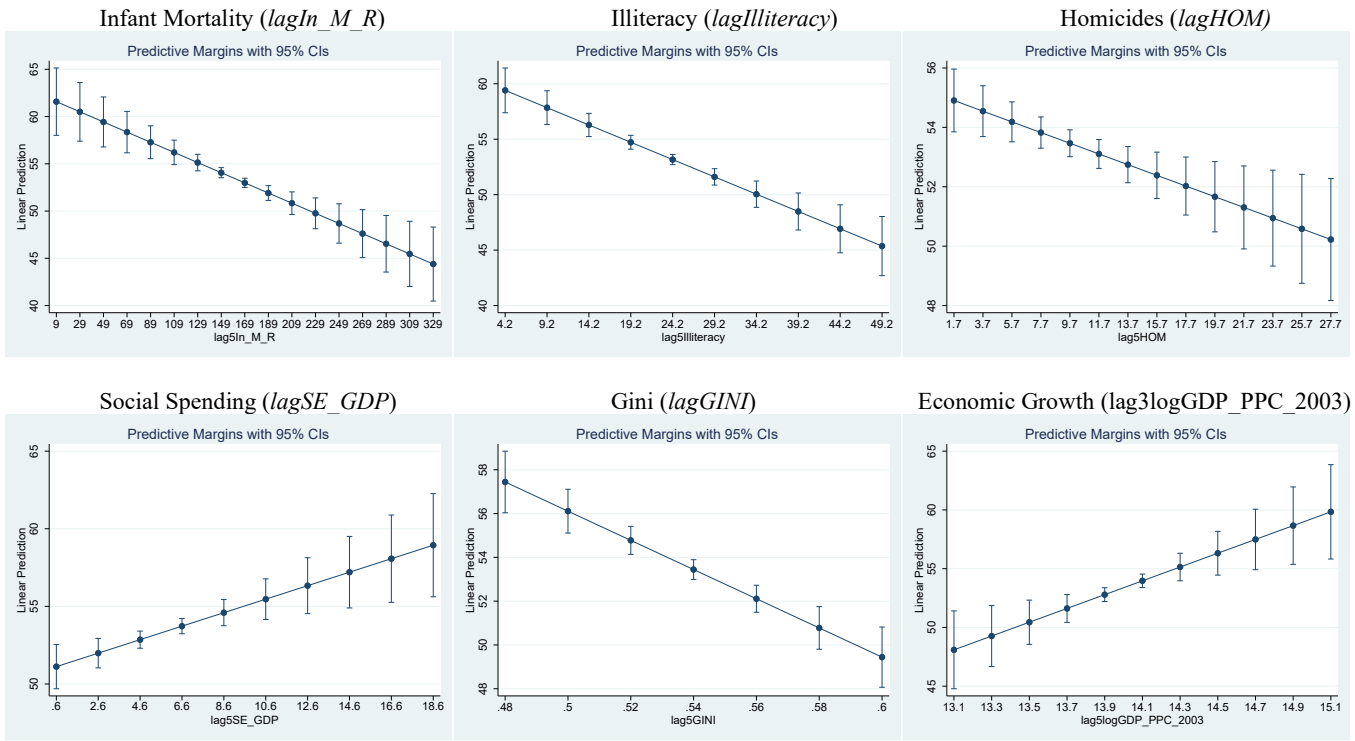
Source: Compiled by the authors.

Figure 5. Probability of longevity (t-3)



Source: Compiled by the authors.

Figure 6. Probability of longevity (t-5)



Source: Compiled by the authors.

Conclusions

This study analyzed the effects of the sociodemographic, economic and political determinants of life expectancy in Chile in the twentieth century. Its main objective has been to evaluate the factors described in the literature affecting longevity in Chile during the twentieth century, with the aim of offering an insight on how government policies affect the lives of people in developing countries more generally. The results empirically illustrate the importance of policies to reduce social inequities and against social violence in order to increase life expectancy.

Between 1900 and 2010, life expectancy in Chile increased in almost 48 years. The results show that illiteracy, economic inequality, homicides and infant mortality had a negative effect on life expectancy throughout this period, confirming and empirically validating many of the conclusions of the historiographical literature on this topic (Collier 2005; Collier and Sater 1998). The results also show that the percentage of urban population, social spending as a percentage of GDP, the political regime and economic growth have positive effects on life expectancy. These results confirm the importance of public policies implemented during the twentieth century in order to increment longevity in Chile.

By differentiating between immediate, short, medium and long-term effects, the models show that the infant mortality rate, the percentage of urban population, the Gini coefficient and the political regime are variables with significant effects on life expectancy. In addition, they indicate that, in the long term, economic growth and illiteracy have more significant effects. The Gini coefficient is significant in both the immediate and long term. Therefore, it is important that governments bear this variable in mind as a crucial aspect of fostering the well-being of society. However, the challenge in this area is how to articulate an economic development strategy that not only favors growth but also seeks to reduce the economic inequality seen in the income gaps that exist in society (Ffrench-Davis 2016).

In sociodemographic terms, the analysis indicates the presence in society of structural factors that affect the evolution of life expectancy as a phenomenon. In this sense, this study shows the importance of taking these factors into account in political, economic and social terms in order to prioritize strategies that favor the evolution of life expectancy in the long term. Undoubtedly, in Chile, the twentieth century proved that the prevalence of effective health policies, economic development strategies and efforts to improve the political regime had satisfactory effects on life expectancy. This situation persisted even during a period of authoritarianism (1973-1990). However, it is also interesting to note that some significant problems remain to be solved in order to improve the health indicators of the population. The most important of these is economic inequality, Chile's most urgent challenge.

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Appendix 1. Summary of variables measurement

Variable	Variable type	Measurement
Infant mortality	Scale ratio	Infant mortality rate per 1,000 live births
Urbanization	Scale ratio	Urban population as a percentage of the total population
Illiteracy	Scale ratio	Illiteracy rate for ages 15 and above
Homicides	Scale ratio	Homicide rate per 100,000 inhabitants
Economic growth	Continuous	Logarithm of GDP per capita in 2003 pesos
Gini coefficient	Scale ratio	Gini coefficient ranges from 0 (complete equality) to 1 (complete inequality)
Social spending	Scale ratio	Percentage of GDP
Polity2	Ordinal scale	The Polity2 index ranges from -10 (autocracy) to 10 (democracy)

Source: Compiled by the authors

Appendix 2. Methodological summary of the variables

Variable	Date	Methodology
Life Expectancy	Lüders, and Wagner (2016)	Based on Gapminder (source url: http://gapm.io/ilex).
Infant mortality	Lüders, and Wagner (2016)	Based on INE (1951, 2014) and Central Bank of Chile (2001).
Urbanization		Based on census records of urban and rural population (1895, 1907, 1920, 1930, 1940, 1952, 1960, 1970, 1982, 1992, 2002 and 2010).
Illiteracy		Based on population censuses, Ministry of Education (2012) and Soto (2000).
Economic growth		Based on Díaz, Lüders and Wagner (1998, 2007). Series expressed in 2003 pesos according to the Central Bank's National Accounts.
Gini coefficient		Based on data obtained from the World Bank, ECLAC, CASEN survey, Prados (2007) and Rodríguez (2017).
Social spending		Based on Jofré, Lüders and Wagner (2000) and the Public Finance Statistics of the Ministry of Finance's Budget Directorate.
Homicides	Rivero-Cantillano et al. (2022)	Based on the statistical yearbooks of the National Institute of Statistics, the National Library and the Civil Registry of Chile. Causes of death are classified as "external causes" as established by the WHO.
Polity2	Marshall, Jaggers and Gurr (2015)	Based on central statistical agencies. Historical reconstructions and estimates made by the authors.

Source: Compiled by the authors.

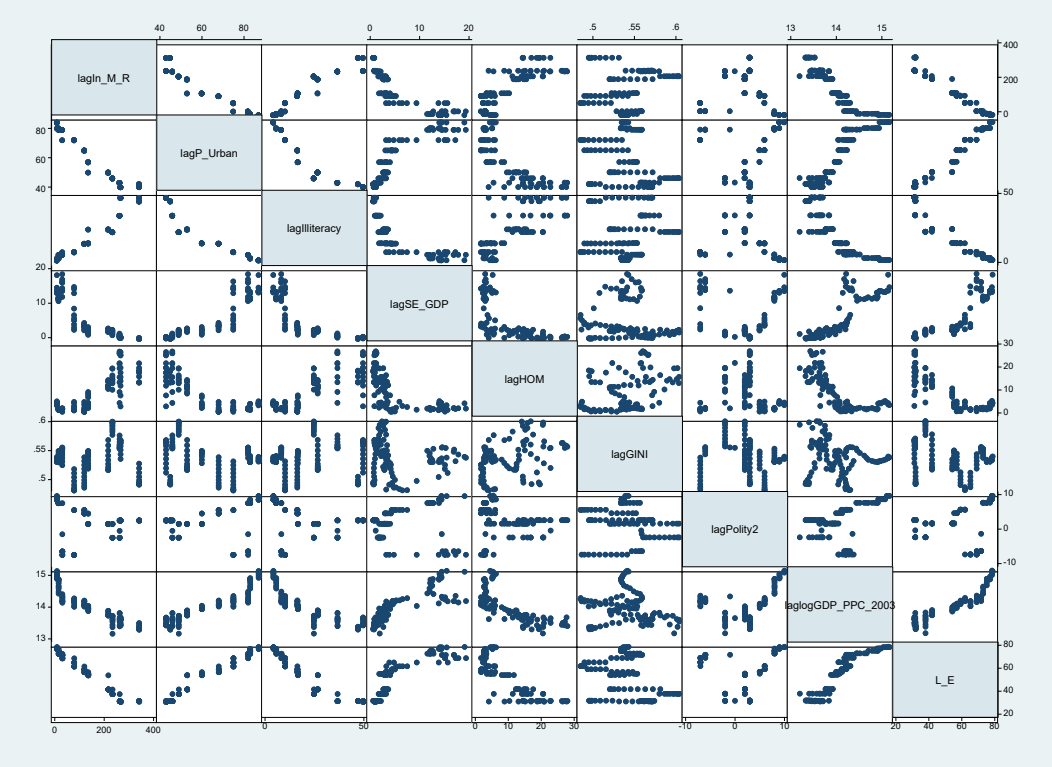
Appendix 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Year	111	1955	32.187	1900	2010
L E	111	52.431	17.284	31.3	78.8
lagIn_M_R	110	155.8455	110.2727	9.3	342
lagP Urban	110	62.418	15.955	43	87
lagIlliteracy	110	22.763	15.454	4.28	49.65
lagHOM	110	9.909	7.628	1.74	27.98
lagSE GDP	110	6.203	5.745	.62	19.4
lagGINI	110	.541	.029	.485	.604
laglogGDP PPC 2003	110	14.044	.497	13.199	15.17
lagPolity2	110	2.391	4.745	-7	10
Lag3In_M_R	108	158.5593	109.4464	9.3	342
lag3P Urban	108	61.963	15.743	43	87
lag3Illiteracy	108	23.106	15.388	4.28	49.65
lag3HOM	108	10.002	7.668	1.74	27.98
lag3SE GDP	108	5.997	5.587	.62	19.4
lag3GINI	108	.541	.029	.485	.604
lag3logGDP PPC 2003	108	14.023	.478	13.199	15.144
lag3Polity2	108	2.25	4.673	-7	10
Lag5In_M_R	106	161.3755	108.5095	9.3	342
lag5P Urban	106	61.491	15.504	43	87
lag5Illiteracy	106	23.461	15.311	4.28	49.65
lag5HOM	106	10.093	7.712	1.74	27.98
lag5SE GDP	106	5.838	5.516	.62	19.4
lag5GINI	106	.541	.03	.485	.604
lag5logGDP PPC 2003	106	14.003	.457	13.199	15.074
lag5Polity2	106	2.104	4.592	-7	9

Source: Compiled by the authors.

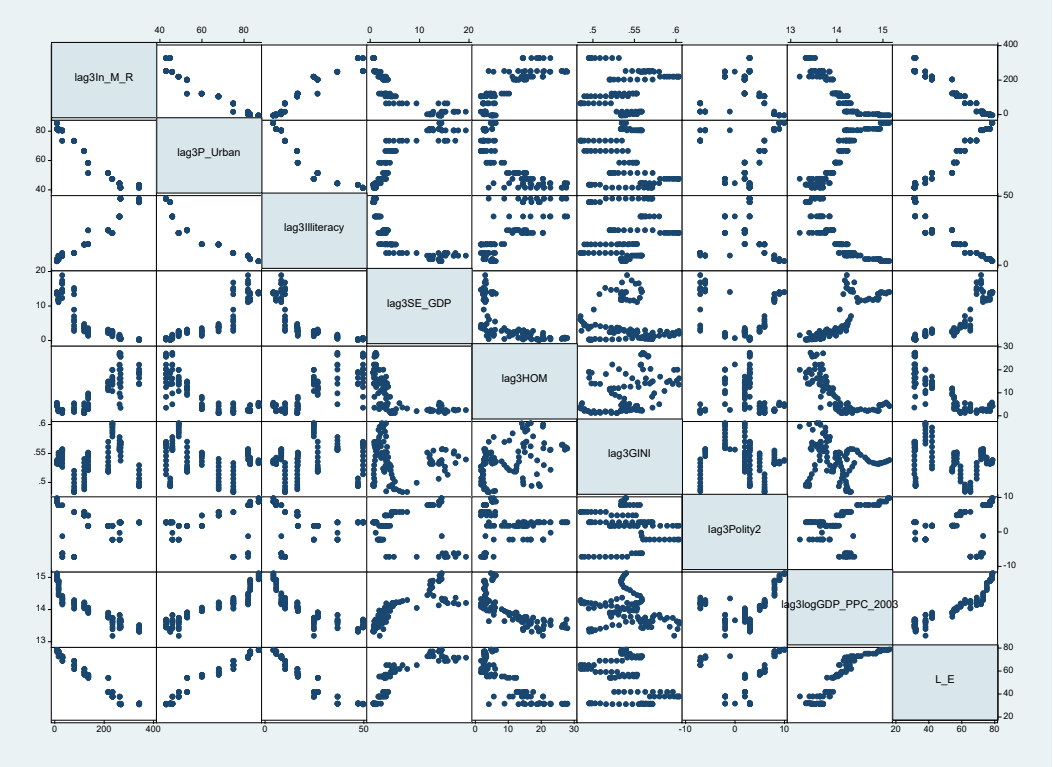
Appendix 4. Descriptive matrix of the relationship of variation between the dependent variable and the independent variables

Appendix 4.1 Moment *t-1*



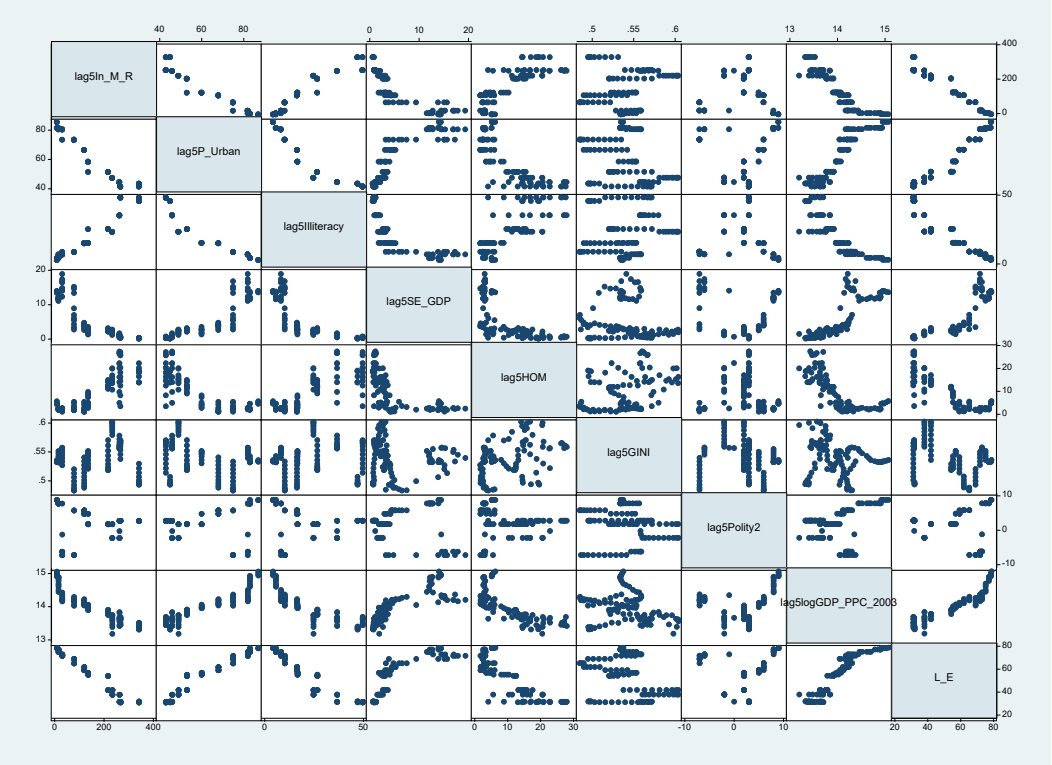
Source: Compiled by the authors.

Appendix 4.2 Moment *t-3*



Source: Compiled by the authors.

Appendix 4.3 Moment *t-5*



Source: Compiled by the authors.