Population aging and healthcare - applying estimators to the projected future of Sweden

Elias Filhage Wahlström

Supervisor: Peter Martinsson

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University of Gothenburg

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Abstract

This paper presents an empirical study on the effects of an aging population on a country's healthcare expenditure. The long-term trend of decreasing fertility rates and increased life expectancy results in a larger share of older people with greater demand for healthcare. This study investigates the macroeconomic effects of population aging by estimating the effects on healthcare expenditure. The estimators are applied to a new demographic projection of Sweden by the SCB (2023b). The results correspond to previous studies and find that a share of older people relative to those of working age and younger increases national healthcare expenditure, both in absolute terms and as a share of GDP. Given the estimated effects and the projected future age distribution of Sweden, healthcare's share of GDP is estimated to progressively increase by several percentage points in future decades. Similar concerns apply to other countries with low and decreasing fertility rates.

Keywords: Population aging; Healthcare; Public finances

Contents

Chapter 1

Introduction

The age distribution of a population is rarely included as a variable in macroeconomic analyses. However, age affects people's economic behavior in many obvious ways; labor participation crucially depends on age, people demand different products at different stages of life, and economic studies have found age to be a significant determinant of decisions in many circumstances. The reason age distribution is rarely considered in macroeconomic analyses is perhaps not that it lacks relevance, but rather because it may be assumed to be constant over time or exogenously driven. However, recent tendencies give reasons to observe the development in the age distribution of societies and study how it may affect the economic decision-making and well-being of people.

The age distribution of a population fundamentally depends on two things, the fertility rate and when people die. Accumulative and exponential technological and economic progression continuously increases the life expectancy of a population, for instance by reducing premature deaths through greater resources available to the production of healthcare. Birth rates are not constant either, and have been included endogenously in economic theories such as the Malthusian theory of population, as described in (Weil and Wilde, 2009). In recent decades, many countries in the world, particularly the developed, have experienced decreasing numbers of children being born. Both of these trends, increasing life expectancy and decreasing birth rates, independently and jointly induce population aging as a result. Population aging refers to the situation in which the average age and the ratio between old and young in a population increases.

The following Figures 1 & 2 show the age distribution, traditionally referred to as the population pyramid, of Sweden in 1900 and 2022 (SCB, 2022). The long-term trend of the last century has been fewer young people and more old people, and many countries that have experienced similar economic growth as Sweden show similar trends.

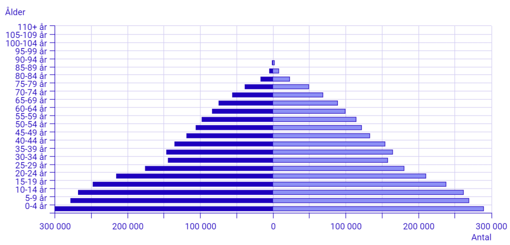

Figure 1: Pop ages Sweden 1900

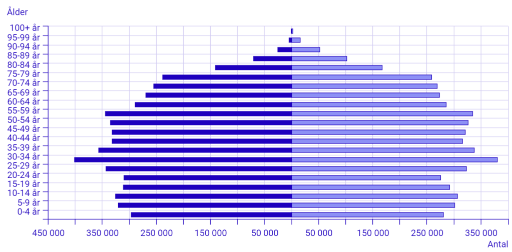

Figure 2: Pop ages Sweden 2022

Many European countries face a similar trend with decreasing birthrates and increase life expectancy (Bivand et al., 2017), and in California, the birth rates are as low as 1,5 per woman (Johnson, 2023). The developments in the age distribution might be a concern for many countries across the globe. For instance, Sweden has been projected to have a significantly shrunken base of younger people and a larger share of older people in the coming decades (Bengtsson and Scott, 2011) (SCB, 2023b).

One implication of population aging is changing the demand and supply of healthcare. Older people consume more healthcare, and if the ratio of people of working age decreases, the capabilities for both private and public funding for healthcare decrease. In a Chinese study, Li et al. (2020) find that the demand for healthcare among people above the age of 65 is more than seven times greater than for people under the age of 25, and similar results are found in a study from eight high-income countries (Papanicolas et al., 2020).

Colombier (2018) says that her research supports the view that the coming population aging will threaten the fiscal sustainability of health systems. An older population affects both the funding possibilities as well as the demand for healthcare services. The healthcare system of most countries has some feature of spreading out the costs of healthcare over time (insurance) or across people (taxes), due to the importance of liquidity constraints in the healthcare market. This means that people of working age, by contributing more to the economy and demanding less healthcare, fund the healthcare needs of seniors on the net. Hence, it makes sense that the age distribution is of critical importance in the problem of healthcare supply.

Healthcare is different than many other sectors since the cost of consumption generally is largely funded by non-consumers, privately through insurance or publicly through the tax system. For instance, it is not certain that the demand equals the supply of healthcare in a public system like that of Sweden, which may be a reason why it has been ranked the most important question in Swedish politics for two consecutive elections (SVT, 2022). The resources available for healthcare in Sweden, as well as in many other countries, have been described as under pressure as it is currently. The projected progressive shift in the age distribution of Sweden may have the effect of further raising the required funds necessary to keep up with the increased demand of the future.

This study is an investigation of such a hypothesis. By collecting and analyzing data on healthcare expenditure and the age distribution of countries across the world, the study estimates the effect of an aging population. Additionally, the estimations are applied to demographic projections of the Swedish population by (SCB, 2023b). In particular, this paper asks the following research questions:

How is national healthcare expenditure affected by the age distribution of a country?

What is Sweden's projected future healthcare expenditure, given demographic projections and the estimated effects of population aging?

This study is primarily concerned with healthcare expenditure as a portion of GDP, but also includes estimations of healthcare expenditure per capita in absolute terms. In this paper, the former is referred to as 'relative healthcare expenditure' while the latter is referred to as 'absolute healthcare expenditure'. The study analyzes country-level data from the World Bank on age distribution and healthcare expenditure, controlling for GDP, population size, and the share of public/private funding of healthcare in 217 countries. The estimations correspond to the hypotheses and the results show that larger portions of old people (in a variety of intervals) significantly increase the healthcare expenditure of a country, both in relative and absolute terms, and the effect is generally increasing for age groups above 60.

Despite assumptions of increased fertility rate and continuous immigration reducing the projected net aging of the population, and not accounting for the estimated effects of income, the demographic projections of SCB (2023b) suggest that the ratio of old to young will continue to increase until 2070. This study estimates that this could lead to an increase in healthcare expenditure's share of GDP by 40 percent (4,3 percentage points) due to the effects of population aging.

The findings align with those of previous research regarding the effect of population aging on healthcare expenditure. This study contributes by applying the estimates to a recent demographic projection and a discussion about how the demand and supply of healthcare may develop in the future. There are reasons to be concerned about the effects of population aging on the economy, especially if it is induced GDP growth.

Chapter 2

Literature review

The literature review presents relevant findings from previous studies regarding the age distribution of populations, healthcare expenditure, and the relationship between the two.

2.1 Population aging

The development of the age distribution in a society may be explained by economic theories. One such attempt is the Malthusian Theory of Population, as described in (Weil and Wilde, 2009), suggesting that there is a core relationship between fertility rates and income, resulting in what is referred to as the Malthusian trap of stagnant economic growth before industrialization. The idea is that fertility rates increase with income because of less restricted economic means to raise children. Currently, developed countries are generally observed to have the opposite relationship, where GDP per capita seems to decrease fertility rates. Figures 3 & 4 below show how the shares of young and old people have developed in OECD countries, according to data from (OECD, 2023a).

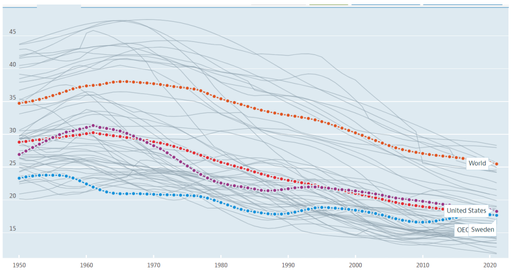

Figure 3: Share of pop aged 0-15 (OECD, 2023a)

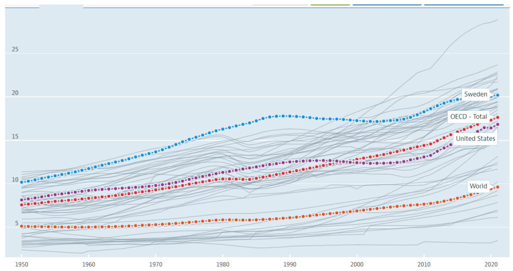

Figure 4: Share of pop aged 65+ (OECD, 2023a)

There are a few possible economic explanations for the long-term trend of population aging. Firstly, as described by Galor and Weil (2000), greater availability of higher quality education may change the economic incentives of having fewer expensive and educated children, while in the absence of sufficient education opportunities, people may choose to have more, less expensive, children. This hypothesis suggests that as the quality, availability, and costs of education increase, fertility rates may continue to decrease in the future.

Another economic explanation for the variation in fertility rates is that women's participation in the workforce increase GDP per capita for obvious reasons, and having children and working may be substitutes in the problem of time allocation to some extent. Hence, economic progression driven by women's increased labor participation may affect the fertility rate. Economic development may also decrease child morbidity, which may have a negative effect on fertility rates. However, the effect on the population age distribution is not clear, as decreased child morbidity may be canceled out by people having fewer children. The effect of women's participation in the workforce and child morbidity are found in (Asumadu-Sarkodie and Owusu, 2016) (Elgin, 2012). This is supported by another study from China, suggesting that the economic growth in the last decade may have caused the problems with population aging the country currently face (Li et al., 2020).

Figure 5 below shows the development in fertility rates for Sweden and other OECD countries. The long-run trends of decreasing fertility rate correspond to Figures 3

& 4 above.

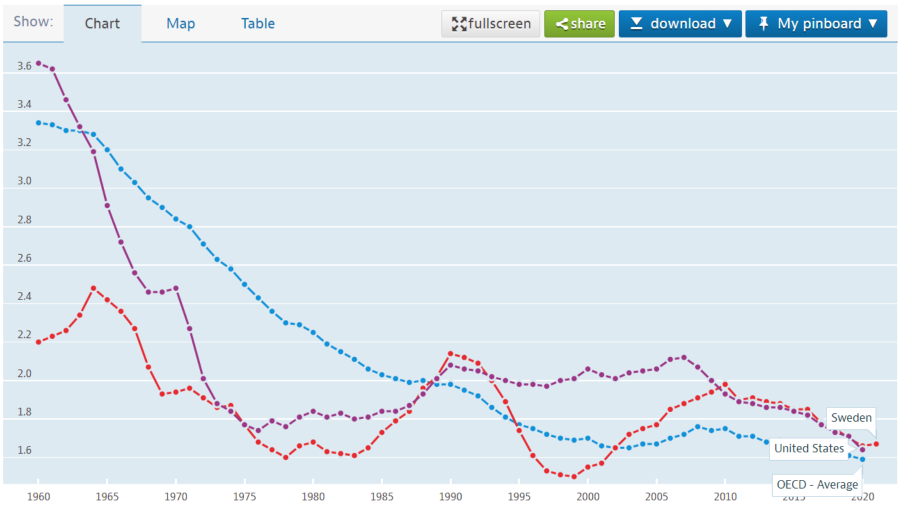

Figure 5: Fertility rate, Sweden & OECD (OECD, 2023a)

The potential long-term relationship between economic growth - which due to the accumulative nature of technological development may be a baseline assumption - and decreasing fertility rates suggest that population aging may be an inevitable development. Economic growth might induce lower fertility rates and increased life expectancy, resulting in net population aging, ceteris paribus.

2.2 Determinants of healthcare demand

Age distribution

Many studies show that the age distribution of a population is a determinant of healthcare expenditures. This is partly because the proneness to diseases and required full-time care depends on the age of a person, as the health status generally decreases as a person gets older (Li et al., 2020) (Colombier, 2018) (Przywara et al., 2010) (Khan et al., 2016). Hence, the relative size of the senior part of the population affects the demand for healthcare. Two studies conclude that the consumption of healthcare services increases particularly above the age of 65 (Papanicolas et al., 2020) (Wong et al., 2012).

Morbidity

There are at least three different hypotheses regarding the morbidity effects of increasing life expectancy on health care expenditure. The dynamic equilibrium/postponement of morbidity hypothesis was proposed in (Suzman et al., 1995). It says that the postponement of death to higher ages due to falling mortality is accompanied by a parallel postponement of morbidity or disability. Consequently, healthy life expectancy grows at about the same rate as total life expectancy. This means that the total number of years spent in bad health remains relatively constant. There is one more pessimistic view called “the expansion of morbidity hypothesis”, and a more optimistic view called “the compression of morbidity hypothesis” (Przywara et al., 2010). Thus, the dynamic equilibrium/postponement of morbidity hypothesis is relatively neutral in its projections.

Income

Income has been found to significantly increase the demand for healthcare, both at the individual and aggregate levels (Khan et al., 2016) (Przywara et al., 2010) (Newhouse, 1992) (Mason et al., 2019) (Ke et al., 2011). Newhouse (1977) found that aggregate income explains about 92 percent of the variance in the level of healthcare expenditure between countries.

Several studies have found income elasticities of healthcare to be greater than one, meaning healthcare is a luxury good (Getzen, 2000) (Blazquez-Fernandez et al., 2014). The richer a country gets, the greater absolute and relative preferences for healthcare. However, the income elasticity of healthcare has lacked consensus in research, where both elasticities of above and under one have been found (Przywara et al., 2010). Getzen (2000) says that “health care is an individual necessity and a national luxury”. By that, he means that the income elasticities of health care are near zero on the individual level, but usually greater than one on a national level. This hypothesis was supported empirically by comparing the results of several earlier studies focusing on both macro and micro levels. This is supported by (Li et al., 2020), who studied the effects of official development on health spending using data from 1995 to 2006 at a country level and found that increases in GDP per capita significantly explained increases in health care spending.

Technological Development

Newhouse (1992) concludes that technological development is a core determinant of healthcare expenditure. With the invention of new productive capital, production becomes more efficient, affecting the production per cost. This is supported by empirical studies, suggesting technology as a determinant of healthcare expenditure (Khan et al., 2016) (Przywara et al., 2010).

According to Sorenson et al. (2013), technology was supposed to account for between 50% and 75% of healthcare costs increases, the figure estimated as the residual left after the effects on the expenditure of demographic change, income, and the other quantifiable factors have been accounted for. However, technological development is hard to measure, as Dreger and Reimers (2005) and Khan et al. (2016) noted. They have used life expectancy as an indicator for technological development's effects on healthcare expenditure.

The technological level of a country may correlate well with GDP, as it is the core determinant of long-term economic growth. Hence, including GDP per capita as a control variable may make the model account for parts of the effects the technological level has on healthcare expenditure. However, it is difficult to project future developments in healthcare technology and account for its effects on the cost of supply.

Life expectancy is also included as a control variable, which may capture the current status of technology in healthcare provision and the morbidity level in the society. Current life expectancy at birth accounts for current morbidity rates, which depend on the status of the healthcare status.

The literature review provides ground for the prediction of population aging, and that it may be correlated with GDP growth. There is a lot of evidence for the hypothesis that a larger relative size of seniors increases healthcare expenditure, as well as income and the technological status of a country.

Chapter 3

Theoretical & Empirical Background

The amount of resources allocated towards healthcare provision should fundamentally depend on two things: the aggregate demand and supply functions of healthcare.

There is no consensus approach to deriving a demand function for healthcare, but the Human Capital Model described in (Culyer et al., 2000) is one established method. People are assumed to get utility from their health status and demand healthcare to maintain the optimal level of health, given the trade-off between healthcare and other forms of consumption. In the context of this study, the predicted effect is the diminishment of the health status after a certain threshhold of age. As the health status decrease, the importance of the health status in an individual's utility function and the optimal level of healthcare demanded should increase. At the aggregate level, this translates into a predicted relationship between population aging and national healthcare demand.

The importance of the demand function in determining the equilibrium quantity may be different in the market for healthcare due to its special conditions in many countries. Perhaps due to concerns about market failure and liquidity constraints among consumers, most countries fund their healthcare through private insurance, publicly through taxes, or a mix between the two. Both approaches are different ways of spreading healthcare expenditure over time (private insurance) or across people (public provision). If the ratio of old to young in a population increases, leading to higher aggregate demand for healthcare, private insurance companies would have to increase the general prices, the premiums for older people more prone to illness, or the deductibles of health insurance to keep up with their increased expenditure of higher rate of interventions. In public systems, the link between the quantity of healthcare demanded and the quantity supplied is less clear since politicians determining the budget for healthcare do not act with market incentives. In countries with democracy, one can assume that an increased healthcare demand would put some pressure on politicians to increase healthcare spending by reallocating the budget or raising taxes, and that the equilibrium quantity of healthcare provision is influenced by demand in that way.

In any system, viewing healthcare demand and the corresponding expenditure for production at an aggregate level, societies will need to reallocate more resources towards the healthcare sector in order to keep up with the predicted increased demand caused by population aging. The size of this reallocation is observed by estimating the effect of the distribution in age on healthcare expenditure relative to GDP.

3.1 Variables

The literature review and theoretical background give grounds for observing the following seven variables in estimating the determinants of national healthcare expenditure.

Healthcare expenditure relative to GDP

National healthcare expenditure relative to GDP is a relevant outcome variable to observe since it measures the portion of resources required for the representative person to allocate toward the supply of healthcare in a country. Observing healthcare expenditure as a share of GDP makes it easier to compare the effects increased healthcare demand has on different countries' economies. The effect of population aging on relative healthcare expenditure accounts for both the effects on healthcare demand, as well as the effects on a country's capability of funding the corresponding supply, i.e. GDP.

Healthcare expenditure per capita

National healthcare expenditure per capita is also relevant to the research questions since it isolates the effects of the demand for healthcare predicted to be dependent on the age distribution of a country.

Age distribution

The predicted effect of age distribution of a population on the country's healthcare expenditure is estimated by observing the share of countries' populations being in different age categories, with a variety of details in terms of age intervals.

GDP

In the context of aggregate demand and supply of healthcare, the effects of GDP per capita on healthcare expenditure may be viewed as the effects of changes in the income of the representative person in a country. GDP almost certainly increases demand for healthcare through the income effect, but it is also possible that people's relative preferences for healthcare are affected by their level of income.

Population size

The population size may have an effect on healthcare expenditure if there are significant returns of scale in the production of healthcare. The production line in most industries has some positive effects of scaling, although the degree varies. If healthcare provisions are more efficient on larger scales, one could expect the population size to be a negative determinant of healthcare expenditure.

Life Expectancy

One limitation of the study, as discussed more in detail later, is the potential problem of reverse causality between healthcare expenditure and population aging. One attempt to control for the effect healthcare provision has on the age distribution of a society is including current life expectancy at birth as a variable. The life expectancy of a country may capture some of the effects the quality of domestic healthcare has on the age distribution.

The government's share of national healthcare expenditure

The core structure of the healthcare system may lead to differences in the efficiency of the production and market for healthcare. One simplified variable controlling for this is the share of healthcare expenditure being spent through the government, as a proxy for the degree of public/private system.

In summary, the hypothesized aggregate demand function for healthcare in the context of this study is outlined in the following equations:

$$AD(Healthcare) = U(Dist(Age), GDPpc, HCefficiency \quad (1)$$

Age threshholds

There are a few thresholds that may particularly interesting to the problem of healthcare expenditure per capita and relative to GDP. It may be a non-linear relationship between the health status and age. Young children may have special medical needs, and the least demanding age in terms of healthcare is later. Working age is defined as an interval between 15 and 64 years old (OECD, 2023b) where people generally start to work full-time and contribute to the GDP. Above the age of 65, people are assumed to be outside of the workforce as the rate of participation in the labor market starts to decrease (OECD, 2023b). As shown in the literature review, above the age of 65, people become increasingly more prone to injury and illness as their natural health status diminishes.

3.2 Hypotheses

Null hypothesis: $\beta_{pop.age} = 0$

Alternative hypotheses: $\beta_{pop.age} \neq 0$

Hypothesis 1: A larger share of the population aged above 65 increases healthcare expenditure relative to GDP. This is tested in Models 1 & 2, and presented in Table 3 under 'Model Estimations'.

Hypothesis 2: Healthcare expenditure relative to GDP and absolute healthcare expenditure are negatively affected by the share of young people (below 0-19) and people of working age (20-64), where the latter effect is stronger. This is tested in Model 3 & 4, presented in Table 4.

Hypothesis 3: The negative effect of a larger share of people of working age is greater on healthcare expenditure relative to GDP than on absolute healthcare expenditure. This is tested by observing the differences between Model 3 & 4 in Table 4.

Hypothesis 4: The positive effect of population aging on healthcare expenditure is increasing with age above the age of 65. This is tested in Model 5 & 6 in Table 5 and Figure 14 & 15.

Hypothesis 5: If hypotheses 1-4 are true, and if the tendencies of population aging persist through the future, the prediction is that the share of GDP spent on healthcare will increase continuously to keep up with the estimated increased demand. To estimate this, the estimated effects of age distribution on healthcare expenditure are applied to the demographic projections in Sweden by SCB (2023b), as presented in Table 6.

3.3 Projection

The Central Bureau of Statistics (SCB) is a Swedish government agency responsible for statistics used for research, private requests, and official assignments from the government (SCB, 2023a). They have made a projection on the future development of the age distribution of Sweden. The projection accounts for historical trends in life expectancy, immigration, and fertility rates. The report has 2022 as a baseline and projects the development until 2070.

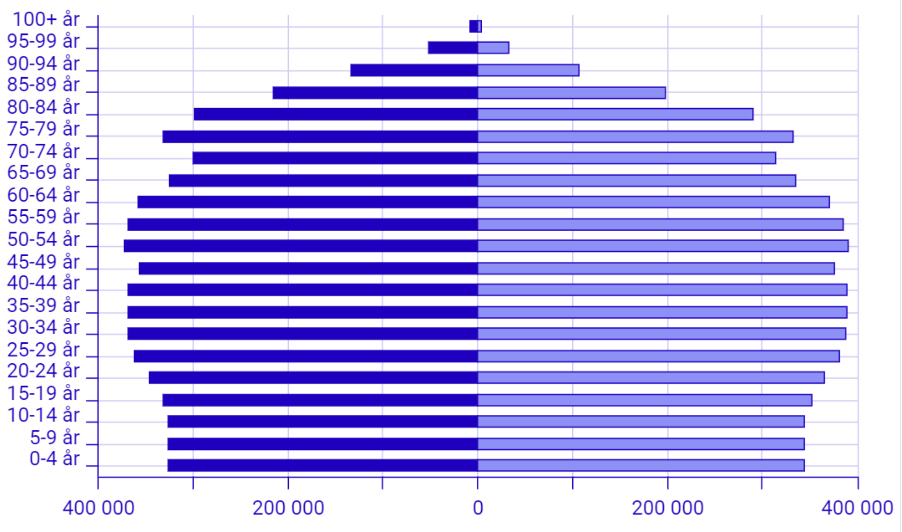

Figure 6: Sweden's projected age distribution 2070 (SCB, 2023b)

Life expectancy is assumed to increase by about five years for both genders, where women are expected to live 90 years and men 88 years. The rate of immigration is assumed to be constant in the long-term corresponding to the current level, where about 100 000 people migrate to Sweden annually. The emigration is assumed to increase slightly, but the net immigration to Sweden is assumed to be close to that of 2022 (SCB, 2023b).

Fertility rates are assumed to increase, both short-and long-term. This is because the birth rate for an individual is assumed to depend on the nation the person was born in (SCB, 2023b). The assumed immigration to Sweden is assumed to contribute to a higher average fertility rate because they were born in other countries. However, it is possible that the country of birth is not the fundamental determinant, but rather cultural influences. Even though people immigrate from other countries, it is possible that a relationship between increased income and fertility rate still persists, and that the Swedish population in general may have a trend of decreasing fertility rates.

The projection does not account for any possible relationship between fertility rate and income and the individual or aggregate level. However, as previously mentioned, there are theoretical suggestions for why there could be a negative relationship, where people's preferences for having children decrease with income.

Figure 7 below shows the assumed development in fertility rate in Sweden. It can be compared to the long-term development of OECD countries in Figure 5.

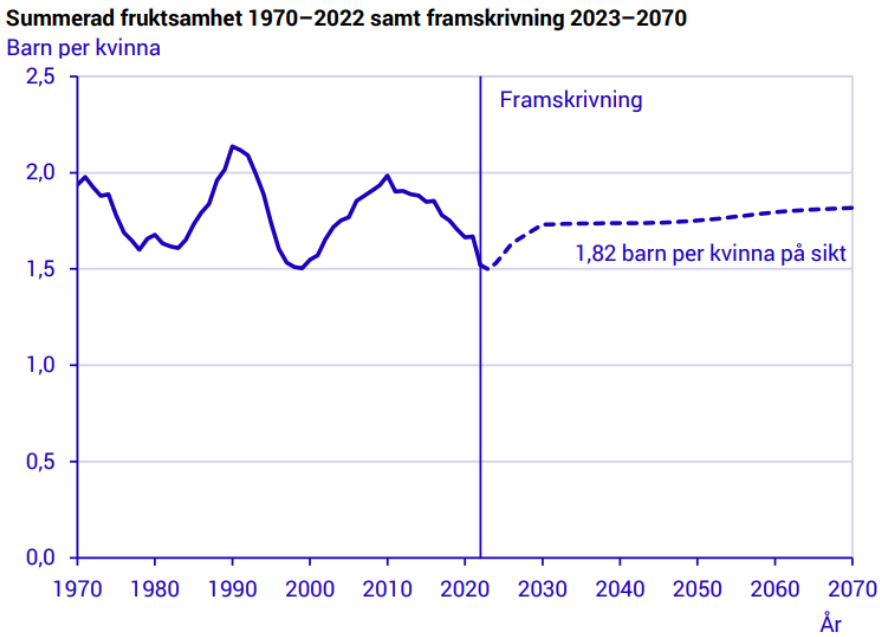

Figure 7: Assumed fertility rate (SCB, 2023b)

Chapter 4

Method

To investigate the four hypotheses and the effects of population aging on healthcare expenditure, the empirical approach is collecting country-level data from (WorldBank, 2023), and analyzing it using OLS regressions. The dataset contains information on relative and absolute healthcare spending and the share of the population in each age category, ranging from 0 to 80+ with intervals of 5 years. The main prediction is that the share of people aged 65 years and above increases both absolute healthcare expenditure and its share of GDP. The study also estimates the effects of populations' age distributions at a more detailed level to see if there are age thresholds of particular interests, and how future developments in the age structures of societies might affect the funding problem of healthcare provision.

4.1 Data collection

The primary source of data is (WorldBank, 2023). The availability of data has played an important role in the empirical strategy of this study. The World Bank has publicly available data on the shares of countries' populations in different age categories. The first age variable is the share of the population being 0-4, and the variables continue with intervals of 5 years, the last variable being people over the age of 80. The database also contains data on healthcare expenditure per capita and as a share of the country's GDP. As of writing this paper, the most recent year data on these variables contained few missing observations was 2019 (WorldBank, 2023). All variables collected are from the year 2019 from 217 countries across the world, and are summarized in Table 1 below.

The study also collects data on the age distribution of Sweden in 2070, as projected by (SCB, 2023b). Applying these projections to the estimated effects of the age distribution on a country's healthcare expenditure is one hypothetical example of how population aging may impact the required reallocation of resources toward healthcare provision in order to keep up with the increased demand. The uncertainties connected to the 50-year projection from SCB (2023b) are acknowledged in the report and depend on a few questionable assumptions of increased fertility rate and continuous immigration, decreasing the projected average age of the population. Despite those limitations, the projections have some value in showing an approximate long-term trend of population aging.

4.2 Econometric models

4.2.1 List of Variables

The following Table 1 presents labels and descriptions of all relevant variables included in the data analysis. "Relative healthcare expenditure" refers to variable CHE, while "Absolute healthcare expenditure" refers to CHEA. All age variables are as a percentage of the total population, and all monetary units are in USD as of (WorldBank, 2023).

Table 1: List of Variables

List of variables		
Variable	Unit	Description
CHE	Share	Healthcare expenditure as a ratio of GDP in country i
CHEA	USD	Healthcare expenditure per capita in absolute terms
pop0004	Portion	The portion of the domestic population aged 4 years and below
pop0509	Portion	The portion of the domestic population aged between 5 and 9 years
...		Continues with intervals of 5 years
Pop80	Portion	The portion of the domestic population aged 80 years and above
Pop014	Portion	The portion of the domestic population aged 14 years and below
Pop1564	Portion	The portion of the domestic population aged between 15 and 64 years
Pop65	Portion	The portion of the domestic population aged 65 years and above
GDP	USD	GDP per capita
GDP2	USD	GDP per capita squared
LE	Years	Life expectancy
GovCHE	Portion	Share of private contribution to health care expenditure

4.2.2 Regression models

The hypotheses derived in the previous chapter are tested by 6 OLS regression models presented below. All models estimate the effects of the population age distribution on healthcare expenditure in a variety of ways. Most models include control variables ($GDP, GDP^2, POP, LE, GovCHE$) to isolate the effects of population age structures to a greater extent.

Model 1 tests Hypothesis 1 by estimating the share of the population aged above

65 (Pop65) on healthcare expenditure relative to GDP (CHE). Pop65 is predicted to be a significant determinant and coefficient β_1 is predicted to be positive.

Model 1: CHE and Pop65

$$CHE_i = \beta_0 + \beta_1 \times Pop65_i + \epsilon_i$$

Model 2 test hypothesis 1 by estimating Pop65 on CHE, but accounting for the potential effects of control variables.

Model 2: With controls

$$CHE_i = \beta_0 + \beta_1 \times Pop65_i + \beta_2 \times GDPpc_i + \beta_3 \times GDPpc^2{}_i + \beta_4 \times POP_i + \beta_5 \times LE_i + \beta_6 \times GovCHE_i + \epsilon_i$$

Model 3 & 4 test Hypothesis 2 by estimating the effects of the share of young people and people of working age on healthcare expenditure relative to GDP, CHE, and absolute healthcare expenditure per capita, respectively. Pop0-19 & Pop20-64 are predicted to explain the outcome variables with negative relationships.

Model 3: CHE and Pop0-19 & Pop20-64

$$CHE_i = \beta_0 + \beta_1 \times Pop0019_i + \beta_2 \times Pop2064_i + \beta_3 \times GDPpc_i + \beta_4 \times GDPpc^2{}_i + \beta_5 \times POP_i + \beta_6 \times LE_i + \beta_7 \times GovCHE_i + \epsilon_i$$

Model 4: CHEA and Pop0-19 & Pop20-64

$$CHEA_i = \beta_0 + \beta_1 \times Pop0019_i + \beta_2 \times Pop2064_i + \beta_3 \times GDPpc_i + \beta_4 \times GDPpc^2{}_i + \beta_5 \times POP_i + \beta_6 \times LE_i + \beta_7 \times GovCHE_i + \epsilon_i$$

Model 5 & 6 test hypothesis 4, estimating the effects of all age groups separately on relative and absolute healthcare expenditure, respectively. The prediction is that there is a negative relationship between absolute healthcare expenditure and the portion of people in age groups below 65, and increasingly strong positive effects for ages above 65. The predictions regarding relative healthcare expenditure are similar, with the exception of young people, whose portions are expected to have a negative relationship two GDP per capita, and thus have a positive effect on healthcare's share of GDP.

Model 5: CHE and Pop ages, detailed

$$CHE_i = \beta_0 + \beta_1 \times Pop\_x_i + \epsilon_i$$

$$\text{where } Pop\_x : (Pop0-4, Pop5-9, ..., Pop80+)$$

Model 6: CHEA and Pop ages, detailed

$$CHEA_i = \beta_0 + \beta_1 \times Pop\_x_i + \epsilon_i$$

$$\text{where } Pop\_x : (Pop0-4, Pop5-9, ..., Pop80+)$$

4.3 Ethical considerations

This study uses aggregate data and does challenge anyone's personal integration and anonymity as individual data is collected. All data used in the study are publicly available from the World Bank (2023), and anyone could replicate this study using the same data set to validate the results.

The study uses global data aggregated data on a country basis and includes almost all countries in the world. The results are therefore general and representative of the global human population. However, there are some concerns with reverse causality limiting the internal validity of the study, which will be discussed further below.

4.4 Limitations

There are a few noteworthy limitations in the empirical strategy of the study. Primarily, the potential of reverse causalities between healthcare expenditure and the population age distribution disturbs the interpretation of the model estimations. One may expect there to be a positive effect of larger healthcare expenditure, and presumably greater provision, on population aging. The point of healthcare is to keep people alive, and if it is successful in that, the population should age on average as a result. However, this effect is not as clear. If a country spends more money on healthcare today, the population may age progressively in the long term, but with little immediate effect on the current age distribution in the population. The predicted effect population aging has on healthcare expenditure is more aligned in time, as the moment a larger share of people are older, they become statistically more prone to illness (Newhouse, 1992).

One attempt to capture the reverse effect between healthcare expenditure and population aging is including life expectancy at birth as a control variable. Life expectancy at birth may capture the effect healthcare expenditure has on population aging as of the current (2019) state of the country. However, one cannot confirm whether the effects in the models can be interpreted as causal or not due to the potential of reverse causality. Another limitation is asymmetric distribution in the age structures of countries, as presented in Figure 11, 12, & 13. For instance, the estimated effect of people over the age of 80 may be biased, since developing countries generally have fewer old people than developed countries. However, including GDP per capita as a control variable may account for these effects.

Regarding the second research question and the future projections and healthcare expenditure in Sweden, there are many methodological limitations and the results should be taken lightly. Firstly, the demographic projection the estimations are based on has great uncertainties, especially for decades far into the future. Secondly, there are many potentially important effects on healthcare expenditure not considered, such as improved efficiency in the production of healthcare that is not correlated with GDP. Thirdly, there are intrinsic uncertainties connected with long-term projections where small estimation errors and scaling effects may have large impacts on the final results.

Chapter 5

Results

5.1 Data analysis

All data presented in this section are collected from the public database of World-Bank (2023). The following Table 2 shows a list of the relevant variables used in the study. There are some missing variables for a few countries, meaning that the amount of observations differs slightly. For the full description of all variables, see Table 1.

Table 2: Descriptive statistics

	Descriptive statiscic				
Variable	Obs.	Mean	Std.dev.	Min	Max
CHE	185	6.501	2.750	1.525	16.767
$CHEA$	185	1144.631	1843.078	19.850	10 921.01
$POP0-19$	217	34.555	12.755	0.213	60.627
$POP20-64$	217	55.659	8.843	0.529	76.689
$POP65$	217	9.329	6.597	0.258	35.597
$GDPpc$	206	18 774.22	27 677.9	216.973	199 377.5
POP	216	3.57e+7	1.39e+8	12 132	1.41e+9
LE	203	73.051	7.555	52.91	85.078
$GovCHE$	185	52.165	21.500	3.355	94.320

The following Figures 8, 9, & 10 below show the distribution relative and healthcare spending, as well as GDP per capita for the countries in the data set. Healthcare expenditure as a share of GDP is somewhat normally distributed, while healthcare expenditure and GDP per capita are heavily right-tailed.

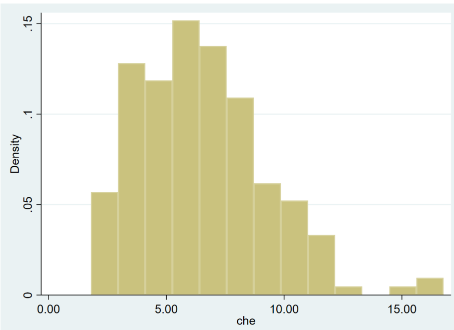

Figure 8: Distribution of healthcare expenditure relative to GDP

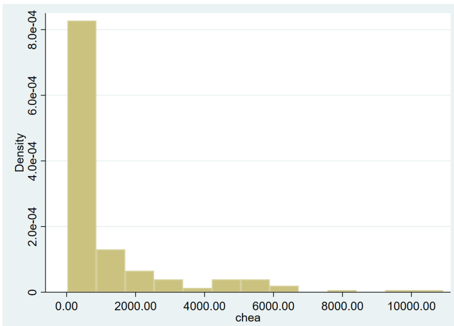

Figure 9: Distribution of healthcare expenditure per capita

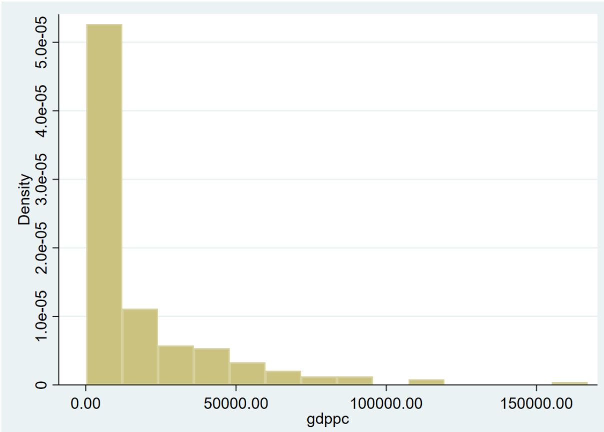

Figure 10: Distribution of GDP per capita

Figures 11, 12, & 13 below show the distribution of the relative size of young, middle, and older people in the data set.

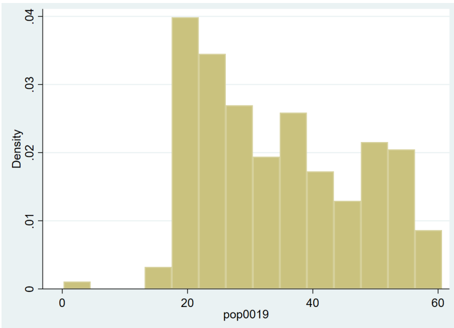

Figure 11: Distribution of portion of people aged 0-19

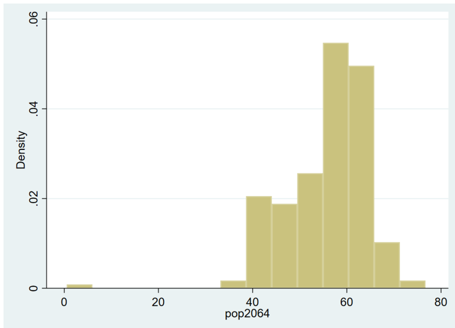

Figure 12: Distribution of portion of people aged 20-64

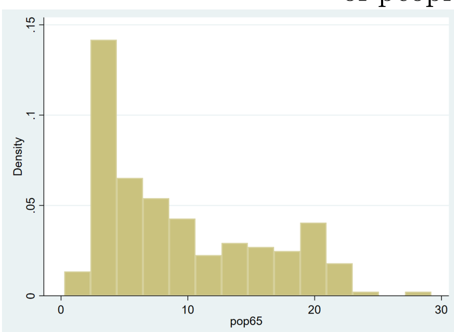

Figure 13: Distribution of portion of people 65 and above

5.2 Model estimations

The following section presents all relevant estimation results of the study, testing Models 1-6.

The following Table 3 presents regression results from Model 1 & 2, testing hypothesis 1. The variable of interest is Pop65, estimating the effect of larger shares of the population being older than 65 on healthcare expenditure relative to GDP. Model 2 control for GDP per capita, Population size, Life expectancy, and the portion of healthcare funding provided by the domestic government.

The variable Pop65 is estimated to be a positive and significant (level 0,01) determinant of relative healthcare expenditure. The coefficients are 1,71 and 2,02, meaning that one percentage point larger share of people over the age of 65 is estimated to increase healthcare expenditure's share of GDP by about 0,2 percentage points.

Table 3: Model 1 & 2

CHE	Model 1	Model 2
$Pop65$	0.171^{***}	0.202^{***}
	(0.028)	(0.039)
$GDPpc$		4.19e-5
		(3.24e-5)
$GDPpc^2$		-2.65e-10
		(3.49e-10)
POP		-1.45e-9
		(1.09e-9)
LE		-0.0040
		(0.043)
$GovCHE$		-0.015
		(-0.011)
$Constant$	4.963^{***}	5.316^{**}
	(0.311)	(2.661)
$AdjustedR^2$	0.167	0.301
Observations	185	174

t statistics in parentheses

$^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

Note: Robust standard errors in parentheses

Table 4 below presents the estimation results from Model 3 & 4, testing hypotheses 2 & 3. Model 3 to the left estimates the effect of the share of young people (0-19) and working-aged people (20-64) on relative healthcare expenditure, while Model 4 does the same with absolute healthcare expenditure. Both models include the same control variables as in Model 2.

Both Model 3 & 4 estimates the effect of Pop0-19 and Pop20-64 to negatively affect relative and absolute healthcare expenditure at significance level 0,01, confirming hypothesis 2. The negative effects were stronger for Pop20-64. The estimations suggest that the relative importance of the share of working-aged people, compared to young people, is greater in Model 4 than in Model 3.

Table 4: Model 3

	Model 3	
CHE / CHEA	Model 3	Model 4
$Pop0019$	-0.187^{***}	-50.839^{***}
	(0.039)	(11.934)
$Pop2064$	-0.276^{***}	-107.881^{***}
	(0.048)	(14.591)
$GDPpc$	4.69e-5	0.105^{***}
	(3.19e-5)	(0.010)
$GDPpc^2$	-3.52e-10	-2.51e-7**
	(3.45e-10)	(1.05e-7)
POP	-1.20e-9	5.41e-7*
	(1.07e-9)	(3.27e-7)
LE	0.074	19.181
	(0.052)	(15.796)
$GovCHE$	-0.012	-4.880
	(0.011)	(3.366)
$Constant$	23.226^{***}	6406.258^{***}
	(5.430)	(1655.365)
$Adjusted R^2$	0.3246	0.8791
Observations	174	174

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Note: Robust standard errors in parentheses

Table 5 below summarizes the individual effects of each age category on relative and absolute healthcare expenditure, respectively.

Table 5: Detailed effects of population age

Age group CHE / CHEA	Model 3 Healthc. exp. relative to GDP	Model 4 Absolute healthc. exp. p.c.
0 - 4	-0.1076^{*}	44.96^{**}
5 - 9	-0.1077	57.17^{***}
10 - 14	-0.1184	86.19^{***}
15 - 19	-0.1027	116.89^{***}
20 - 24	-0.2669^{*}	41.68
25 - 29	-0.4723^{***}	-146.35^{***}
30 - 34	-0.3966^{***}	-203.56^{***}
35 - 39	-0.4656^{***}	-302.33^{***}
40 - 44	-0.3710^{**}	-331.54^{***}
45 - 49	0.0333	-191.51^{***}
50 - 54	0.3056^{**}	-58.59
55 - 59	0.3475^{***}	-12.72
60 - 64	0.3841^{***}	7.24
65 - 69	0.4905^{***}	43.88
70 - 74	0.6607^{***}	108.73^{**}
75 - 79	0.7938^{***}	126.27^{**}
80 +	0.4742^{***}	53.73
Observations	182	182

$^{*}\, p < 0.10$, $^{**}\, p < 0.05$, $^{***}\, p < 0.01$

Model 5 to the left estimates significant negative effects of the relative size of the age groups 0-4 and ages between 20-44, and significant positive effects for age groups over 50.

Model 6 to the right estimates significant positive effects of age groups between ages 0-19 and 70-79, and negative effects between ages 25-49. Both models estimate increasing positive effects for ages above 65, with the exception of the last group with people above the age of 80.

The figures below show how the portion of each age interval is estimated to affect relative and absolute healthcare expenditure, based on the data from Table 5 above. Although there are similar patterns, Figure 14 & 15 below present two differences between models of relative and absolute healthcare expenditure. The portion of younger people is estimated to slightly decrease relative healthcare expenditure, but has a clear positive effect on absolute healthcare expenditure. Additionally, the negative effect of working-aged people is stronger for absolute healthcare expenditure.

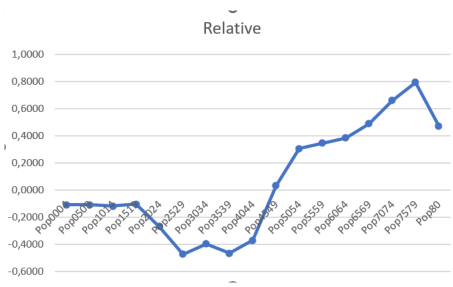

Figure 14: Pop ages on healthcare exp. per capita

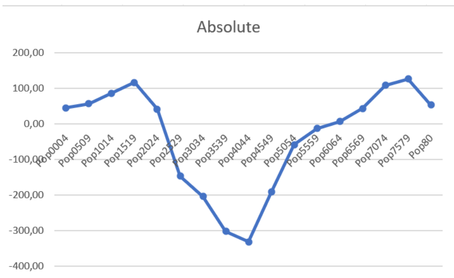

Figure 15: Pop ages on healthcare exp. relative to GDP

5.3 Predicting values for Sweden

According to the projections made by SCB (2023b), Sweden's population would have an age distribution by 2070 as shown to the left in Table 6 below. The estimated coefficients of each age group from Table 6 are in the middle column, and the predicted effect on healthcare expenditure relative to GDP is to the right.

Table 6: Detailed effects of population age

Age group	Projected change	Estimated coefficient	Predicted effect
0 - 4	−0.56	−0.1076	0.060
5 - 9	−0.75	−0.1077	0.081
10 - 14	−0.56	−0.1184	0.067
15 - 19	−0.08	−0.1027	0.008
20 - 24	−0.17	−0.2669	0.046
25 - 29	−1.34	−0.4723	0.631
30 - 34	−0.87	−0.3966	0.344
35 - 39	−0.29	−0.4656	0.135
40 - 44	−0.19	−0.3710	0.070
45 - 49	−0.68	0.0333	−0.023
50 - 54	−0.64	0.3056	−0.196
55 - 59	0.02	0.3475	0.008
60 - 64	0.24	0.3841	0.090
65 - 69	−0.10	0.4905	−0.048
70 - 74	−0.64	0.6607	−0.420
75 - 79	1.20	0.7938	0.950
80 +	5.40	0.4742	2.562
Total			4.365

The total accumulated effect of the projected age distribution of Sweden is estimated to increase healthcare expenditure relative to GDP by 4,365 percentage points, or 40%, from 10,87 in 2019 to 15,23 in 2070. More than half of the increase comes from the projected increase in the share of people above the age of 80.

Table 7 and Figure 16 presents the estimated projected increase in relative healthcare expenditure over time. The graph shows a somewhat linear estimated long-term increase in healthcare's share of GDP in Sweden.

$$CHE_{20XX} = (\delta Pop04_{20XX-2019} * \beta_{Pop04}) + ... + (\delta Pop80_{20XX-2019} * \beta_{Pop80})$$

Table 7: Projection

Year	CHE	Change
2019	10.8675	
2030	11.9239	+1,0564
2040	13.4901	1,5663
2050	13.9677	+0,4775
2060	14.8280	+0,8603
2070	15.2307	+0,4027

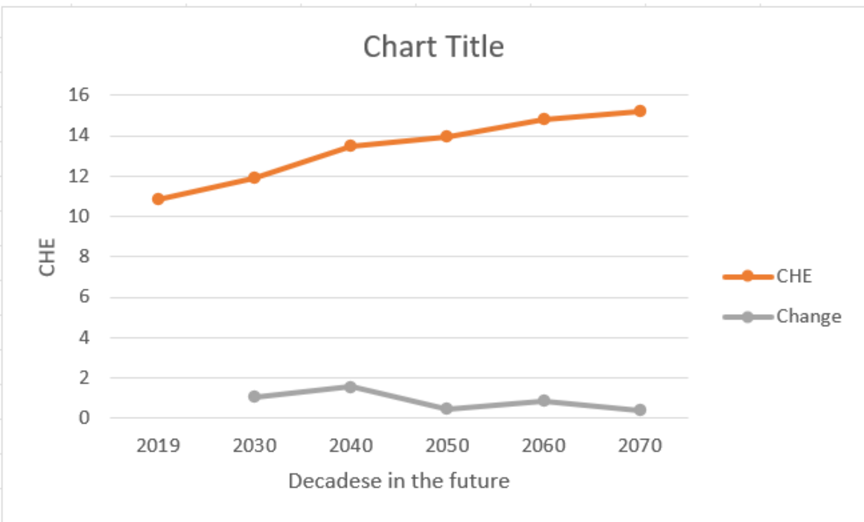

Figure 16: Projection of Sweden

Chapter 6

Discussion

The findings of the study provide evidence in favor of the predictions made initially. The null hypothesis of no significant effect can be rejected for hypotheses 1 & 2. The results suggest that hypotheses 4 & 5 are also true, although with less confidence, while the study cannot reject the null of Hypothesis 3. In summary, there is clear evidence suggesting that an increased share of older people increases healthcare expenditure, while the differences between relative and absolute are less clear. The estimated effect of the age distribution of a population generated across countries on a global scale is applied to Sweden's projected demographic development. The study estimates that population aging may increase healthcare's share of GDP by more than one percentage point per decade on average.

The theoretical prediction is that the demand and supply of healthcare depend on the age distribution of the population in a country. The demand is predicted to increase with age, particularly above the age of 65, due to increased proneness to illness and injuries. The projected development of population aging in Sweden is predicted to induce a long-term progressive increase in the share of GDP being spent on supplying an increasingly old population with healthcare.

The findings of the study generally correspond to the predictions. The four hypotheses are all confirmed by the model estimations in the results finding that larger shares of older people significantly increase healthcare expenditure, both as a share of GDP and in absolute terms per capita. There are a few thresholds in age estimated to be of particular importance in the context of healthcare expenditure. All age groups (intervals of five) below the age of 20 are found to significantly increase the healthcare expenditure per capita of a country, while the relative size of age groups between 25 and 49 is found to significantly decrease it. The effect is estimated to be positive for age groups above 60, but only 70-74 & 75-79 are significant. One explanation is that the statistical power is limited because many countries in the data set have relatively few old people (see Figure 13).

Sweden, having experienced similar trends as many other developed countries in terms of population aging, is projected to have its population progressively become older, which is estimated to increase healthcare expenditure relative to GDP by 40% in 50 years due to changes in the age distribution.

The findings of this study correspond to the results of previous studies (Li et al., 2020) (Papanicolas et al., 2020) also studying the effects of population aging on healthcare expenditure. The projections and concerns raised by Colombier (2018) about long-term economic effects from continuous population aging is supported by this study's estimations of Sweden's future development.

There are some noteworthy limitations in the methodology of the study. Firstly, limitations in data made the study unable to account for critical factors potentially explaining the variation in healthcare expenditure between countries, such as the technological level, market conditions, and local factors of climate and diseases. Parts of such variation may be captured by controlling for GDP per capita.

The potential impact of reverse causality between healthcare expenditure and the age distribution of a population disturbs the interpretations of the estimation results somewhat. There is reason to believe that increased spending on healthcare provision increases the share of older people. However, this relationship should be lagged, and increasing the budget for healthcare today may have little effect on the current age distribution. The impact of reverse causality may thus depend on how correlated healthcare expenditure is over time.

Perhaps the most concerning hypothesis of this topic is that there is a long-term decrease in fertility rates associated with economic growth. As seen in Figures 3, 4, & 5, the recent history point towards decreasing fertility rates and population aging in the long term for OECD countries. As long as the fertility rate is below two, especially if it is decreasing further, population aging is inevitable. Unless future improvements in the efficiency of healthcare production are sufficient to counter it, population aging may cause healthcare expenditure to keep raising in size relative to GDP. Hence, the critical variable seems to be the fertility rate, and one approach to address the potential economic threats could be to incentivize having children.

The production costs of healthcare services are often funded by non-consumers through health insurance or taxation. As the resources required for supplying an increasingly old population with healthcare services of a certain standard, it is not certain that the supply will equal the demand unless the economic system has mechanisms to coordinate the market for healthcare sufficiently well.

A subject for future research is to bring a more detailed understanding of the determinants of fertility rate and the preferences for having children. The changed trends in fertility rates over the last centuries are probably the main driver behind population aging, and the estimated healthcare expenditure attributed to it.

One critical factor not considered in this study is the efficiency of the healthcare production of a country. Increased healthcare demand due to population aging may be countered by improved healthcare markets, and future studies are encouraged to investigate how societies could address increased healthcare expenditures through improved efficiency.

6.1 Conclusion

This paper concludes that the age distribution of a population affects the healthcare expenditure of a country. The estimation corresponds to those of similar previous studies. The estimated effects suggest that Sweden's healthcare as a share of GDP may increase by 40% until 2070 due to the projected increased share of older people in SCB (2023b). One critical component is the trend of decreasing fertility rates in many developed countries, and this study finds that the required funds for maintaining the current standard of healthcare in Sweden will increase in the coming decades due to population aging.

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