Universität Zürich[UZH]

Thesis

To optain the degree of

Master of Advanced Studies in Real Estate

A 2040 projection of Switzerland’s residential prices

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List of abbreviations

ADF	Augmented Dickey–Fuller test
EU	European Union
fig.	Figure
FSO	Swiss Federal Statistical Office
GDP	Gross Domestic Product
GNP	Gross National Product
OADR	Old-age dependency ratio
NTA	The National Transfer Accounts
SNB	Swiss National Bank
UN	United Nations
USA	United States of America
VAR	Vector autoregression
VEC	Vector error correction
WP	Wüest Partner AG

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Abstract

This study aims at assessing whether the predicted strong aging process of the Swiss population for the next 20 years will negatively affect residential real estate prices. An empirical analysis with a VAR model on times series over a recent historical period of 40 years was performed. The obtained results do not suggest that aging has a significant detrimental impact on the prices of residential properties in Switzerland. In consequence, the conducted simulation, which was based of the empirical model, could not confirm the hypothesis of a prospective decrease in residential real estate value by 2040.

1. Introduction

There are various parameters which may impact the demand for residential real estate and ultimately its prices. According to the published literature and empirical research, economical factors have, on the demand side, the most significant explanatory power for real estate prices. Consequently, the economic environment and the applied economical & monetary policies do influence the evolution of residential real estate prices. However, the usual timeframe of a full economical cycle has been for over a century, not longer than a decade in average.

As reflected in the title, I am interested in this thesis to assess whether a prediction for the next 20 years of the evolution of the residential real estate prices is realistic. This timeframe is disproportionately too long for an economical forecast, however it corresponds to a generation and is ultimately associated with demography. The total population growth and the evolution of the structure of the population of a country have also an explanatory power of the evolution of the real estate prices. According to demographers, developed countries will experience a so-called longevity demographic transition during the 21st century. This demographic phenomenon involves a relative increase of the older portion of the population which may ultimately have an impact on the valuation of financial as well as real assets. In the case of Switzerland, demographers predict that in the coming two decades, until 2040, the relative size of the post-retirement portion of the population shall experience its strongest growth.

The key hypothesis I am attempting to evaluate in this research is that the above described aging phenomenon and its predicted high intensity in the next 20 years will negatively impact the residential real estate prices in Switzerland.

1.1 Research objectives

The research objectives are fourfold. I first aim at identifying the dynamic as well as the challenges associated with the aging of a society. This assessment is made from a demographic perspective and from an economic perspective. The second research objective is to model the theoretical economic dynamic of residential real estate investing across generations. The review of the past literature on the topic falls withing the second research objective as well. The third research objective aims at assessing empirically the explanatory power of demographic and economical variables on residential real estate prices. The fourth and last objective of this research is to determine whether the obtained empirical results can be used to make predictions for residential real estate prices in the next two decades.

1.2 Scope of study

The first theorical part of the research covers the implication of aging in the fields of demography and economics. The Implications from a sociological, architectural, or urbanistic perspective are not covered. The second theoretical part of the study focuses on the theoretical modeling of the utility of a residential property from an individual perspective across two time periods in life, namely the active and the post-retirement years. The investment or buy-to-let facets of residential real estate is not modelized.

The empirical part of the study as well as the simulation have Switzerland as a geographic scope. The empirical analysis is based on yearly times series of variables across a period of 40 years spanning from 1975 to 2015. The simulation covers more than two decades, from 2015 to 2040.

The econometric empirical approach is a stationary VAR ("Vector autoregression") model. The analysis of a VEC ("Vector error correction") model is not explored.

1.3 Research design

The research is divided in 3 main sections:

- Section 1 – introduces the research theme and the main hypothesis
- Section 2 – reviews the demographic and economic challenges associated to an aging society. It also performs a theoretical modeling of homeownership across two generations.
- Section 3 – it outlines the econometrical analysis and its results. it also describes the simulation approach and discusses the limits of such an exercise.
- Section 4 – it concludes the performed research.

2. Background

2.1 The demographic challenges associated with aging

2.1.1 Demography

Demography can be broadly defined as the field associated with the census and the analysis of the population. Historically speaking two different aspects of the demography can been identified. A first one relates to the study of the impact of the increase or decrease in population on the well-being of groups of individuals. The existence of such analysis and studies dates back to ancient China and Greece. A second aspect of demography has a scientific approach theorizing how and why the population variates. This aspect has been initiated in the 17th century (Kammeyer & Ginn, 1986, pp. 12-13).

There are 3 key demographic variables: Fertility, mortality and migration. Theirs measurement results to the analysis of population growth or decline over time**.** They are most of the time expressed as rates, measuring the frequency of the analyzed event in relation to a defined population. The population taken in consideration can be the total population or a specific population which may be more associated with the considered variable.

1. Fertility: The fertility rate is calculated by comparing the number of births in a year to the total number of people in one population. The latter can be the whole all-age population or just the female population in age of bearing children.
2. Mortality
    a. Mortality rate: It is calculated by comparing the number of deaths in a year to the total number of people in one population. The latter can be the whole all-age population or portions of the population on the age scale which may be more at risk such as infants and elderly people.
    b. Life expectancy at birth: using the current recorded death rates for each age in a population, it is the average of years a newborn may expect to live.
3. Migration rate: its calculated by comparing the number of people migrating in and out of an area in a year to the total number of people in the population of the area.

When it comes to analyzing or comparing a population, age and sex are the two main characteristics used (Kammeyer & Ginn, 1986, pp. 1-6).

Those above central parameters in relation to the study of the evolution of a population are highly relevant to the understanding of the phenomenon of aging.

2.1.2 The Projection of the population

The methods applied to make projections of the population are broadly based on past trends and the assumption that the present dynamic affecting fertility, mortality and migration will sustain in the future. The main methodology used to gauge the uncertainty associated with projection is to run 3 different probabilistic scenarios: low, medium and high probability (Piggott & Woodland, 2016, pp. 11-12).

The main model currently used for projections is the cohort-component method. This approach is graphically illustrated in fig. 1 here below. The first step of the method is to divide the population at the beginning of the projection by age and sex cohorts. In a second step, to determine the population surviving at the end of the projection interval, the cohorts are applied a survival rate which is derived from the current mortality data or some simulation models. In a third step, the projections of migration rates are calculated for the projected interval. The rate can be based on the current values or different simulation models. The net migration figure is then added to the survival number of persons resulting in a projection of the survivors born prior to the coming period. In a fourth step, the number of births within the projected period are forecasted. This is performed by determining the birth rate of the female population in each cohort. The birth rates are defined either by using recent data or different simulation models. At the fifth and last step, the number of births is added resulting to the total population by age and sex at the end of the projection interval. The obtained population serves as a basis for projecting the total population at the end of the next interval. The process is repeated until the complete projected period is covered (Smith, Tayman & Swanson, 2013, pp. 48-49).

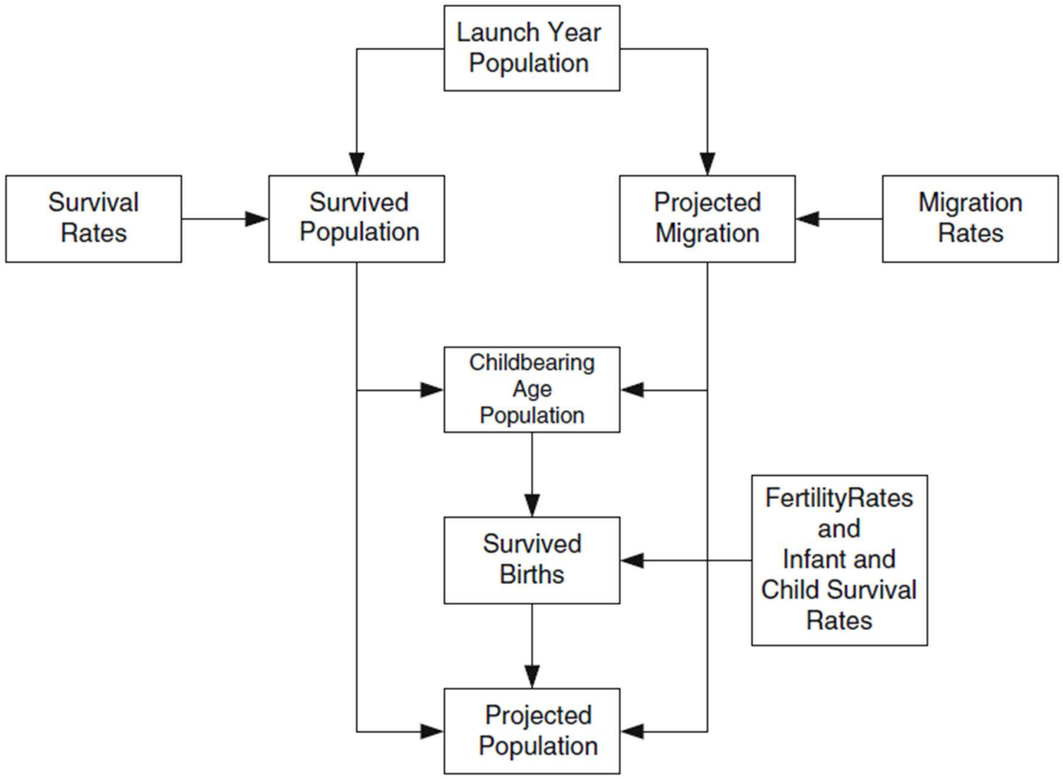


Figure 1: Overview of the cohort-component method (Smith, Tayman & Swanson, 2013, p. 48)

The accuracy of the projections for a population is an important topic. The total global population projections performed by the UN ("United Nations") have shown in the past a rather high level of accuracy. However, the accuracy of projections for specific age groups, namely among the youngest and the oldest portions of the population, have provided less accurate results. The projected levels of fertility rates and mortality rates among elderly groups tended to be overestimated. The accuracy of projections has been relatively more challenging for developing countries. Two reasons explain that. First, the limited quality of the data provided and second, many of those countries are still going through a traditional demographic transition. Nevertheless, in the last decades, the projections of the older age groups for developed countries have also seen strong adjustments from the UN. For instance, during the 1994-2000 period, the UN 2050 projections for the age 80+ share of the population among developed countries have seen a +25.33 % adjustment (Piggott & Woodland, 2016, pp. 11- 14). The net migration is another variable which may significantly affect the accuracy of projections. It has been the main source of population growth among developed countries since 1950. Shifts in net migration for single countries are due to short term changes in the economic situation and changes in policies, which may have long term migration impact (United Nations, 2017, pp. 1-3). Among the three demographic components, migration is the one which has seen the least attention from the research community. Consequently, the current accuracy of its projections has high potential for improvement (Piggott & Woodland, 2016, p. 146).

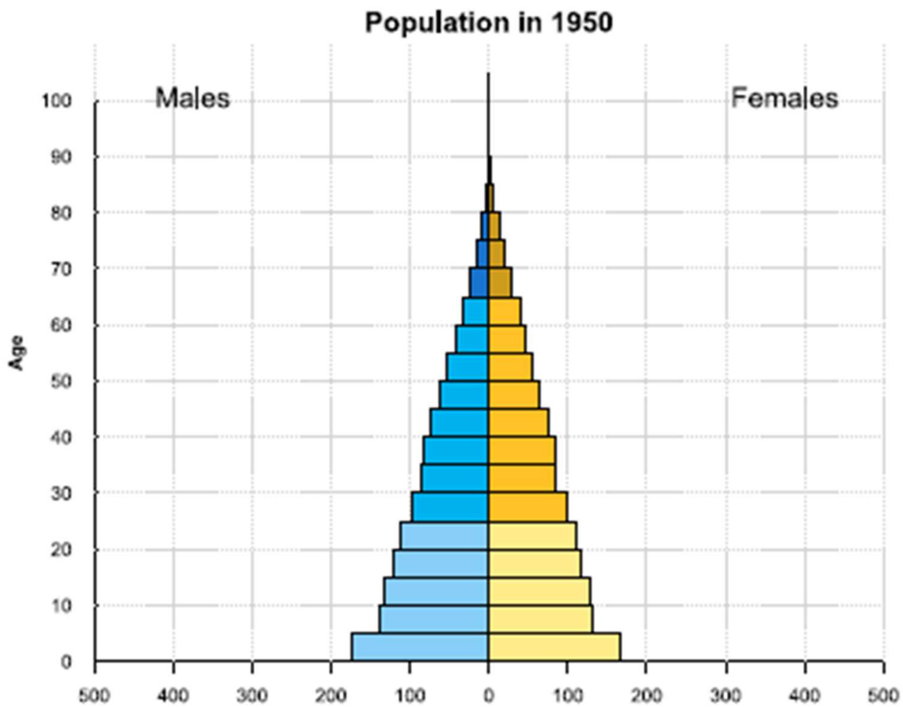
2.1.3 Demographic aspects of the aging population

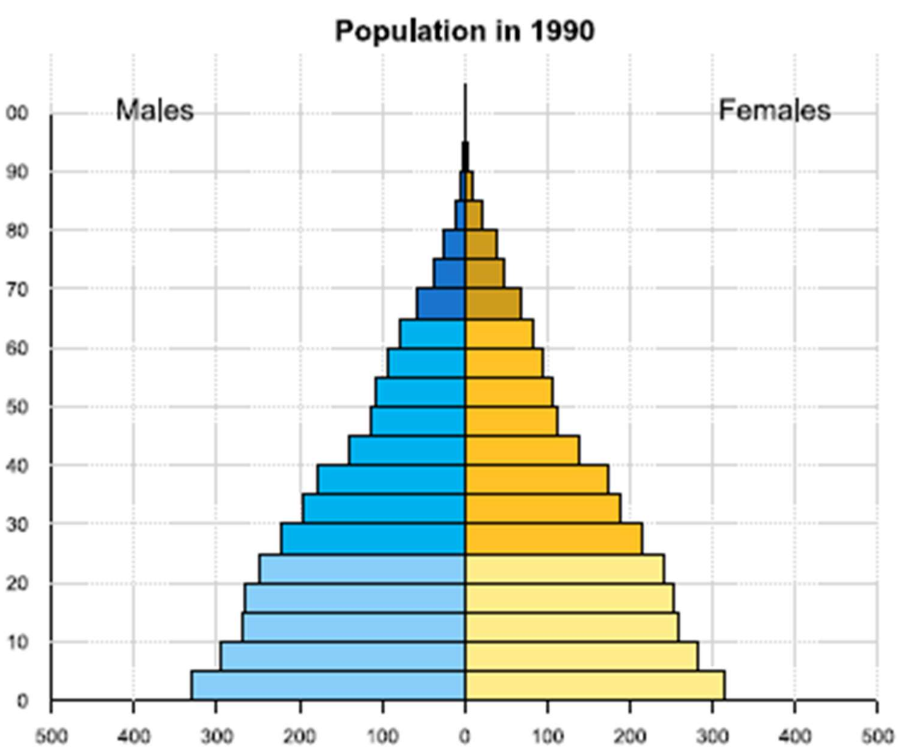
Starting in the early 19th century in European countries, strong improvement in hygiene standards and medical know-how (Szreter, 2004) contributed initially to the so-called demographic transition. This phenomenon is associated with a first strong decline in mortality, especially among infants, which generates afterwards larger cohorts among the working age groups of the population. This first phase is followed, usually with a lag, by a decrease in fertility. Those two consecutive steps generate an increase in population which prior to those evolutions tended to be stable (Eggleston & Fuchs, 2012).

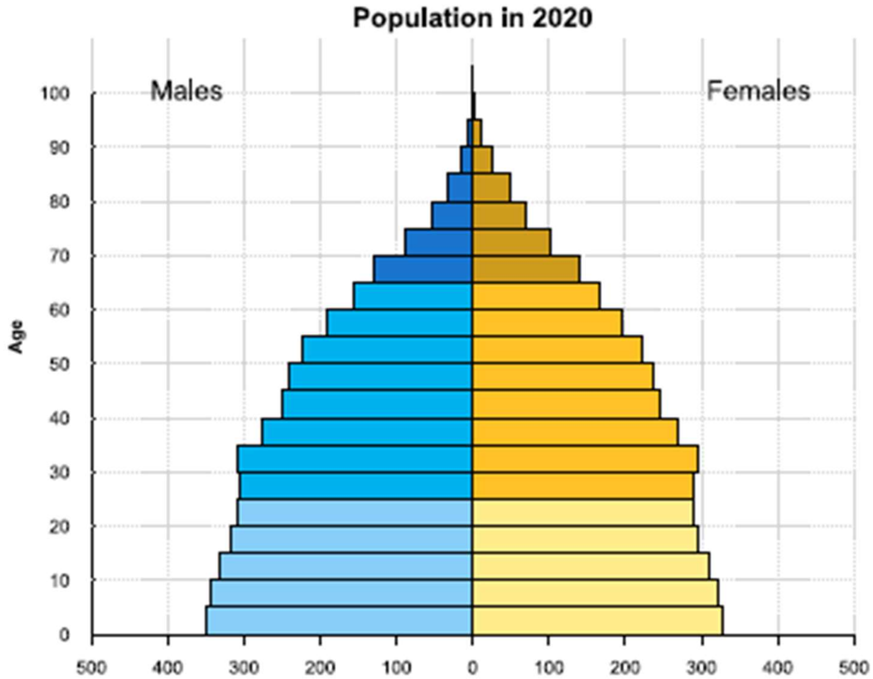
A new demographic transition is currently taking place in many countries around the world. In comparison with the historical demographic transition, this new process involves an increase in years of life expectancy not at an early age but rather in the later phase of life, generating an increase in longevity. The historical transition saw, at the beginning of the 20th century, many countries at a similar stage of development experiencing the greatest gain in life expectancy among young and working age cohorts. Only 20% of the gain was generated among the elderly population. At the beginning of the second decade of the 21st century, 75% of the gain in longevity is taking place among the post-retirement cohorts. As we will explore in more details in the next section, this phenomenon requires to be assessed beyond the retirement of an unusually specific cohort, namely the "baby boomers" (Eggleston & Fuchs, 2012).

The global aging phenomenon is projected to experience its strongest growth until 2040. After that, the relative size of the elderly population will continue growing, though at a slower pace, up to the end of the century (Piggott & Woodland, 2016, p. 4). Fig. 2 here under shows the world population pyramids between 1950 and 2100 (United Nations, Department of Economic and Social Affairs, Population Division, 2019). The displayed projections of the population's pyramid, are based on the UN medium fertility scenario. The age structure of the world population has seen a major evolution from 1950 until now. The size of the young age cohorts has seen substantial growth resulting in a total population growth of more than 4.5 billion individuals. Concerning the future evolution of the structure of the world population, the UN forecasts an increase of the percentage of population aged 65+ from 8.2% in 2015 to 15.9% in 2050. At the bottom of the population age pyramid, the percentage of individuals under 15 shall decrease from

26.2% in 2015 to 21.1% in 2050. A slight decrease is predicted for the other cohorts during that period. Thanks to the above described improvement in life expectancy, the total population is predicted to increase further from 7.3 billion in 2015 to reach a peak of about 10.8 billion by 2100.






Population in 2020
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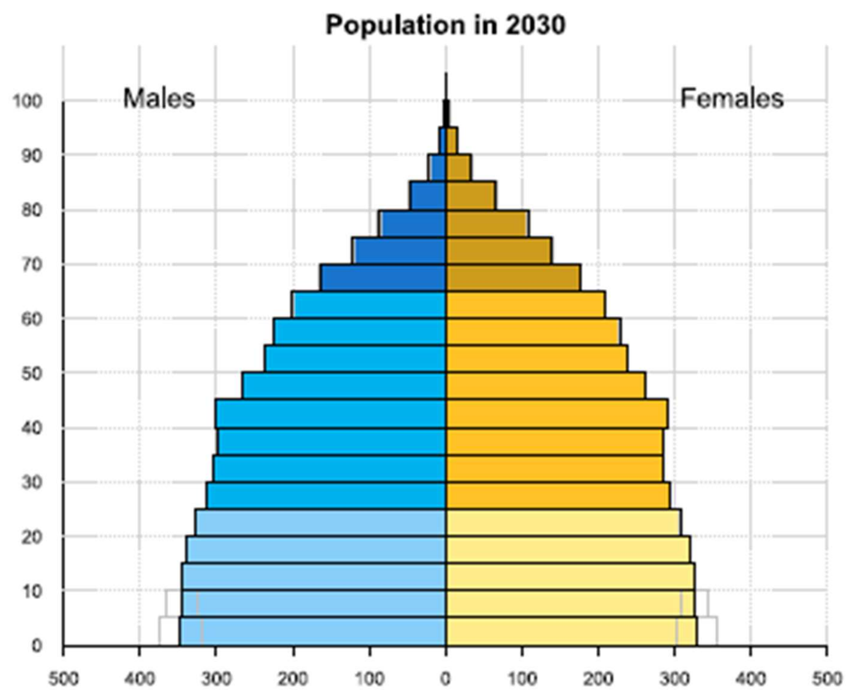
Population in 2030
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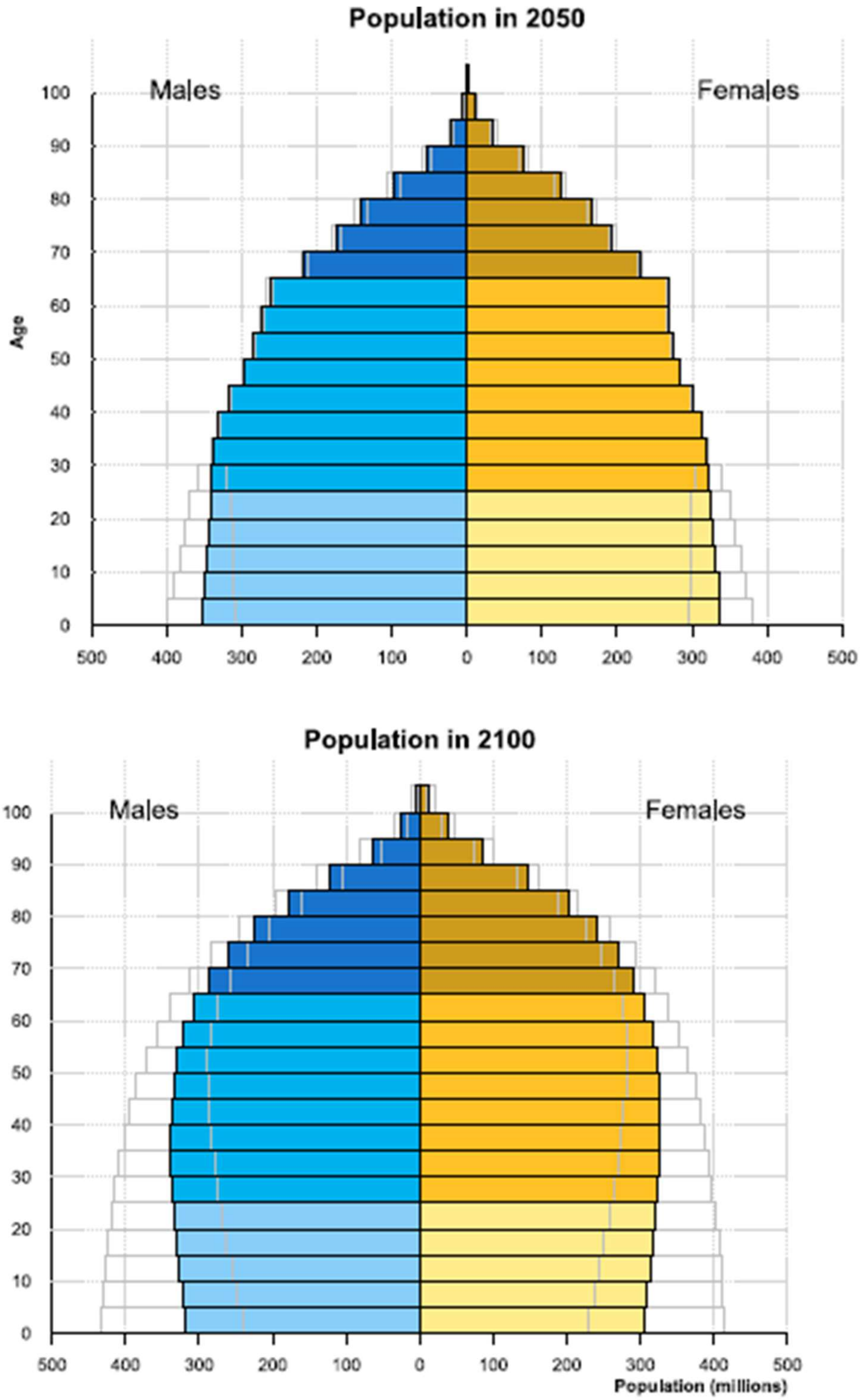


Figure 2: World population age pyramids between 1950 and 2100 (United Nations, 2019, pp. 2-3)

An important characteristic of the longevity demographic transition is the progression of the old-age dependency ratio ("OADR"). OADR measures the relation between the older portion of the population, aged 65+, and the working age cohorts (Piggott & Woodland, 2016, p. 10). As the below fig. 3 shows, OADR has seen globally a slight increase since the 1970's with a ratio currently above 10%. Worldwide, the UN predicts a strong and steady increase over the rest of the 21st century to reach a level above 35% by 2100.

Regarding the more developed countries, OADR has a current level of above 25%. The UN predicts a strong growth until 2060 followed by a more moderate increase. The projected 2100 OADR for those regions of the world is above 50%. This metric depicts the effort required by the working cohorts and therefore the most productive portion of the economy to support the elderly cohorts.

The measure of OADR by the UN and other supra- and national organizations is somehow arbitrary. It is centered around the institutionalized idea that 65 years old is the age after which people are defined as elderly. However, a distinction needs to be made between the chronological age of a person and her physical stage of health and her vigor. Across the 20th century, the latter have seen a strong improvement and thus for any age. Consequently, if based on physical attributes, the projected increase in aging in the 21st century is much lower for the developed countries. For the OADR to follow suit, an institutional and cultural adjustment regarding the definition of the retirement age or its transitioning would need to take place (Piggott & Woodland, 2016, p. 63).

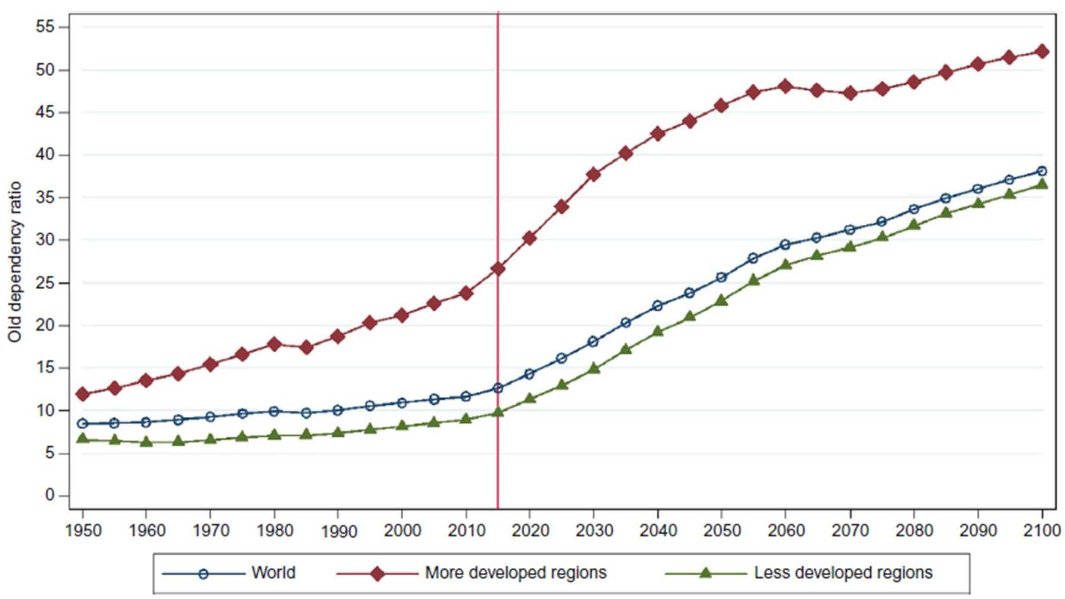
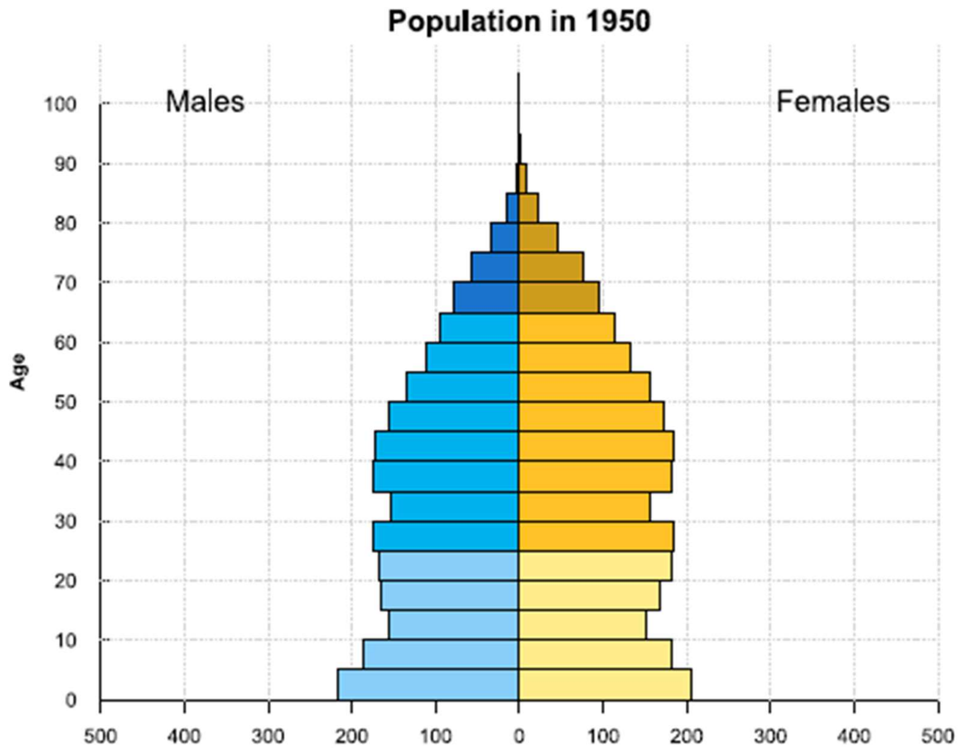


Figure 3: Old-age dependency ratio (in percent), by level of development, 1950–2100 (Piggott & Woodland, 2016, p. 10).

2.1.4 The aging population phenomenon in Switzerland.

The aging process in Switzerland has clearly seen an initial development in the second half of the 20th century. The median age, in years, went from 33.2 in 1950 to 42.2 in 2015. The percentage of the population aged 65+ years went from 9.4% in 1950 to 18% in 2015 United Nations, 2019, p. 1083). The UN projects a continuation of this process in the 21st century as illustrated in the graphs of fig. 4 here below.


Population in 1950
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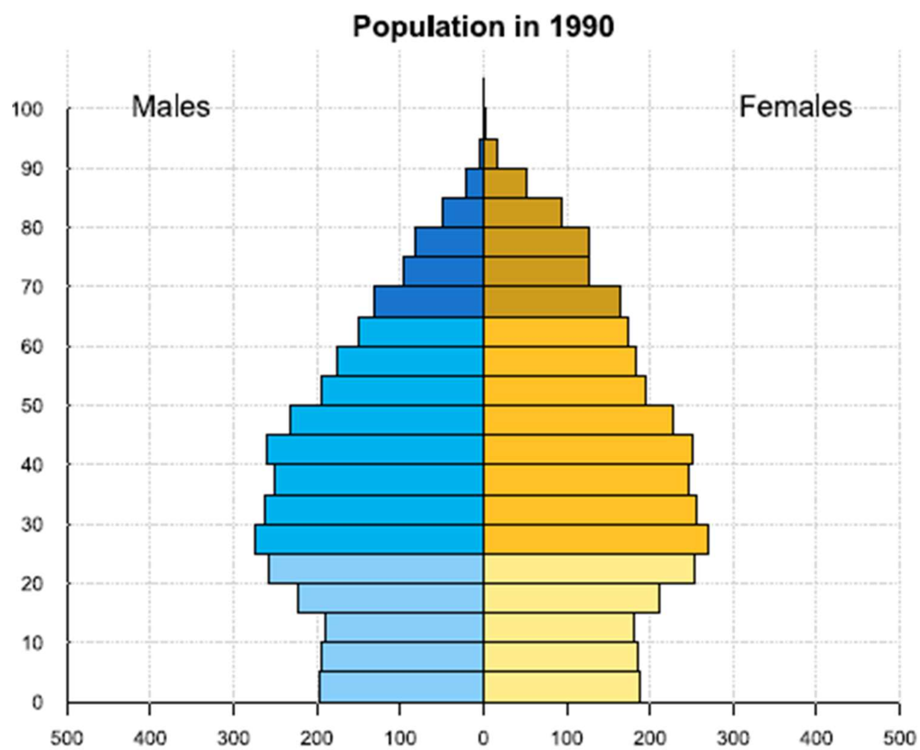
Population in 1990
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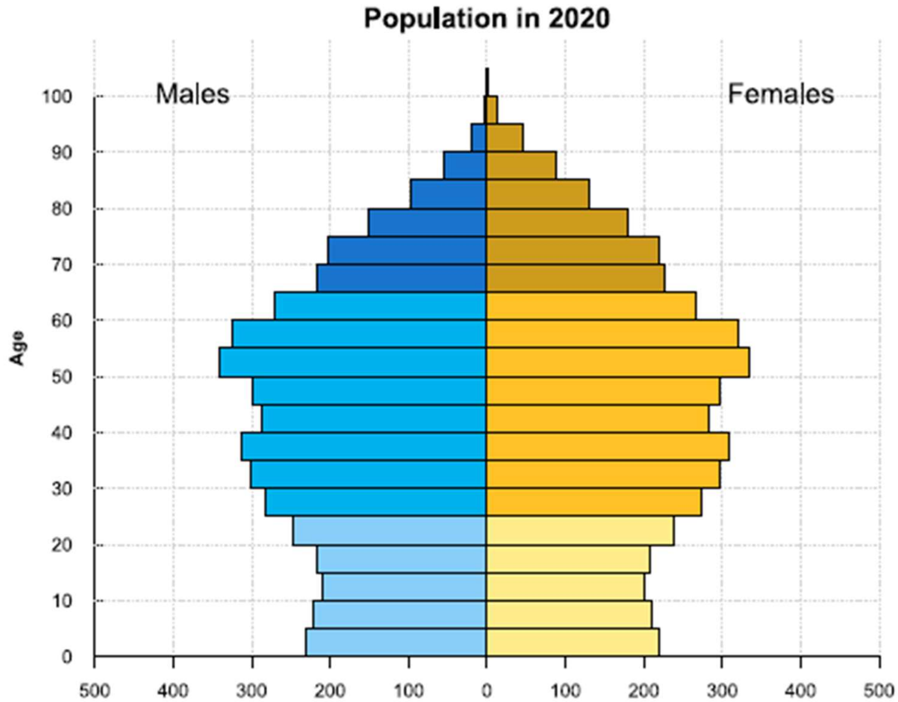
Population in 2020
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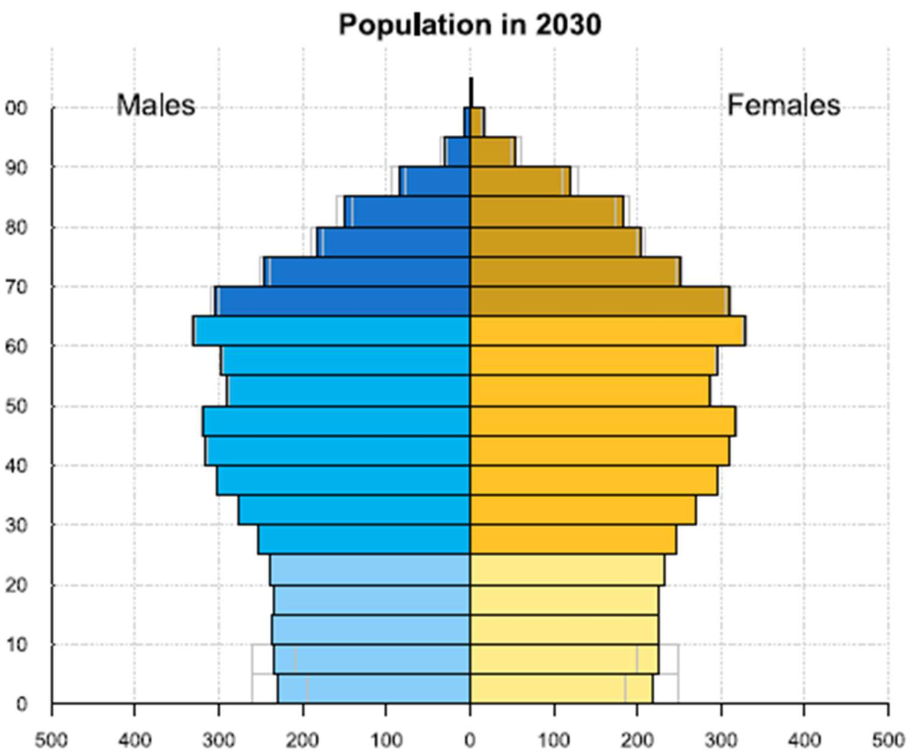
Population in 2030
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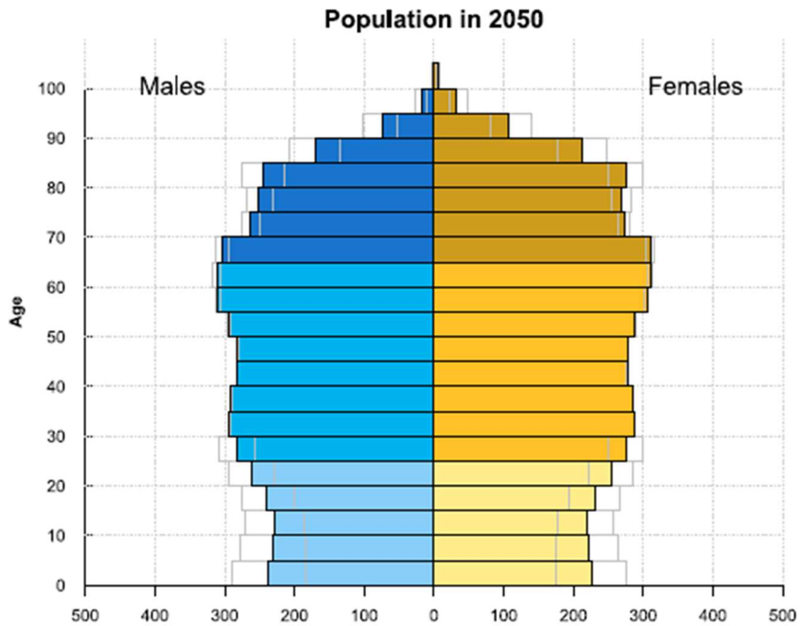

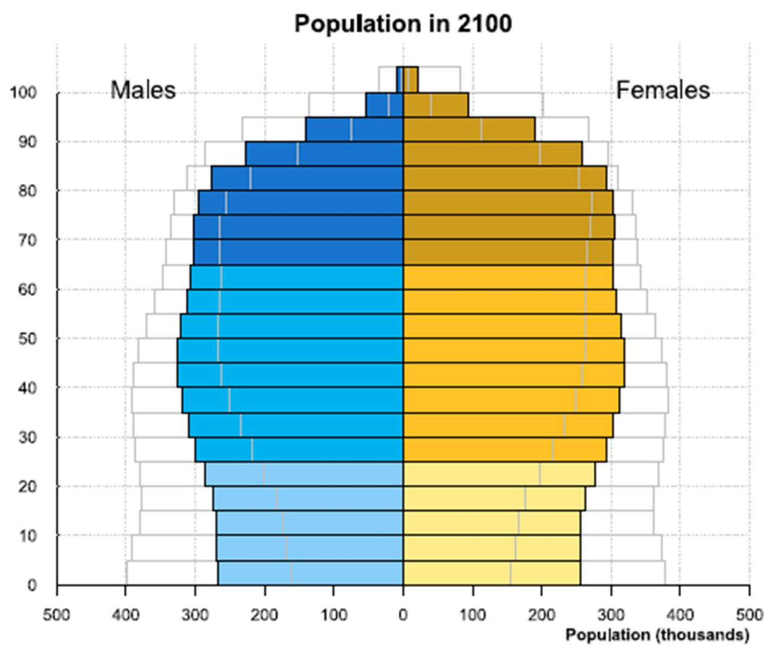

Figure 4: Switzerland population pyramids between 1950 and 2100 (United Nations, 2019, pp. 1080-1081).

The population projections performed by the Swiss Federal Statistical Office ("FSO"), prior to the emergence of the Covid-19 pandemic, are based on three socio-economical probabilistic scenarios: medium, called reference scenario and denominated a "A", high called "B" and finally low, "C".

The reference scenario assumes a relative strong attractivity of Switzerland, thanks to high quality of life, a resilient economy, a central geographical situation, and a favorable taxation. The lacking workforce is brought in from the European Union ("EU"). However, the levels of this migration are not as high as in the past decade. This is due to the economic recovery in the EU. Consequently, after 2030, the net migration decreases though remains positive up to 2050. Thank to pro-family policies, the fertility rate sees a slight increase. However, the increase of women with higher education results in an increase of the average age of motherhood. The life expectancy continues to progress thanks to medicine developments and healthy lifestyles.

The high scenario assumes a relatively strong Swiss economy. The gap between Swiss real wages and those in the EU remains and even expands with some countries. The net migration of the working age population increases to fill the gap with the retiring baby-boomers. After 2030, the net migration decreases due to the aging of the population in the EU, resulting a stronger demand in workforce. The fertility increases thanks to pro-family policies and a foreign migration with a fertility rate higher than the domestic one. The life expectancy sees also a strong progression due to the medical development and the spreading of a healthy lifestyle.

The low scenario assumes an economic growth lower than for the reference scenario resulting to a stable net migration up to around 2030. In the longer term, the net migration decreases due to a weak domestic economic growth. The aging process in all of Europe also impacts negatively the net migration in Switzerland due to the increased competition for highly skilled workforce across the continent. The fertility decreases slightly in the coming decades as more women focus on their career and undergo greater and longer education paths. The initiated policies to ease work, life and family balance for women are too modest to counterbalance the trend. As foreign women have a greater fertility rate than nationals, the weaken net migration also contributes to the decrease in fertility. Additionally, the weak economic development also contributes to less widespread healthy lifestyle than for the reference scenario. Consequently, the life expectancy progression is slower.

The FSO foresees with its reference scenario a further progression of the Swiss total population though at a slower pace, resulting to a 20% increase between 2020 and 2050. The proportion of young people remains quasi stable. The active part of the population decreases from 61% in 2020 to 55% in 2050. The elderly portion of the population sees a rapid progression from 18.9% in 2020 to 25.6% in 2050. This development is especially pronounced during the 2020-2030 period as a large number of baby-boomers retire.

As shown in fig. 5 here below, OADR is foreseen to increase substantially up to the half of the 21st century. The current (2020) OADR is of 30.1%. The reference scenario of the FSO projects an increase to 46.5% by 2050 (Swiss Federal Statistical Office FSO, 2019).

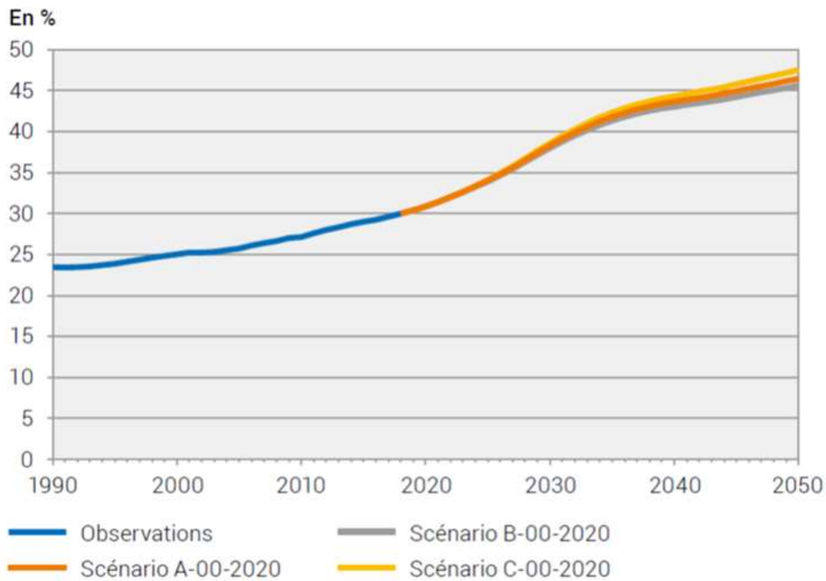

Figure 5: The evolution of the OADR (%) according to the A, B and C scenarios (Swiss Federal Statistical Office FSO, 2020, p. 3).

2.2 The economy and aging

Piggott and Woodland (2016) preconize the use of dynamic simulation models to analyze the effect of the longevity transition in the 21st century on an economy. The empirical analysis of transfer of flows and basic steady-state models help to identify three characteristic features: 1. The relation between the age pattern of consumption and the labor income over life. 2. Whether the gap between labor income and consumption is compensated through transfers or by drawing on assets accumulated through earlier saving and whether the transfers made are asymmetric with age. 3. The aging of the population contributes to a more capital intensive economy which has an influence on wages, profits and interest rates (Piggott & Woodland, 2016, pp. 83-84).

2.2.1 Redistribution of income across generations and age patterns of consumption

In developed countries especially, the consumption of the retired population is greatly relying on the transfers from the active portion of the population. This dependence is particularly strong in the last few years of life, mainly due to a large medical and assistance care. Consequently, the above described longevity transition may unbalance the economy of a country. Economists have been recommending adopting policies to improve productivity, incentivize savings and postpone retirement (Fuchs 2012).

The relation between consumption and income through the years of an individual is illustrated in fig. 6 here below (Piggott & Woodland, 2016). One can notice in the graph, the strong increase in consumption in the very later years of life among high income countries. The National Transfer Accounts ("NTA") is an UN project with the goal of better understanding the generational economy. The aggregated data of 60 nations are used to generate economic flows across generations. The research of the NTA touches upon different policy topics such as family, education, health care or welfare (United Nations, undated).

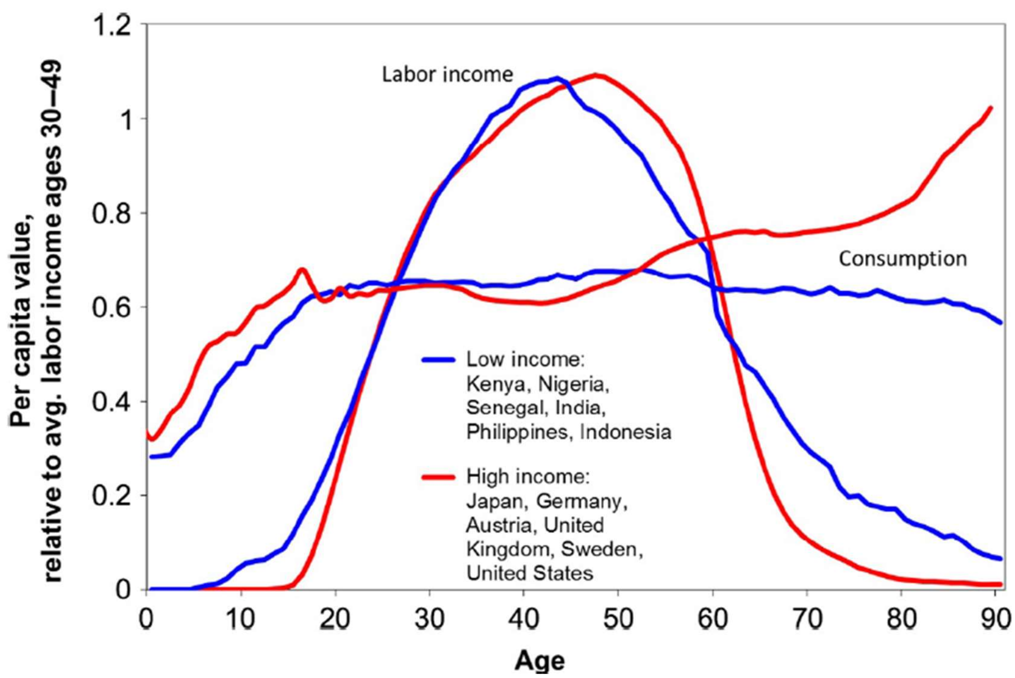

Figure 6: Labor income and consumption age profiles from NTA averaged for six low income and six high income countries (Piggott & Woodland, 2016, p. 65).

The transfer or reallocation processes to support consumption in periods of life where it excesses labor income, are in the number of three, according to the origin of the flows: Public transfers, private transfers, and asset income. Fig. 7 here below illustrates this phenomenon for the United States based on NTA data.

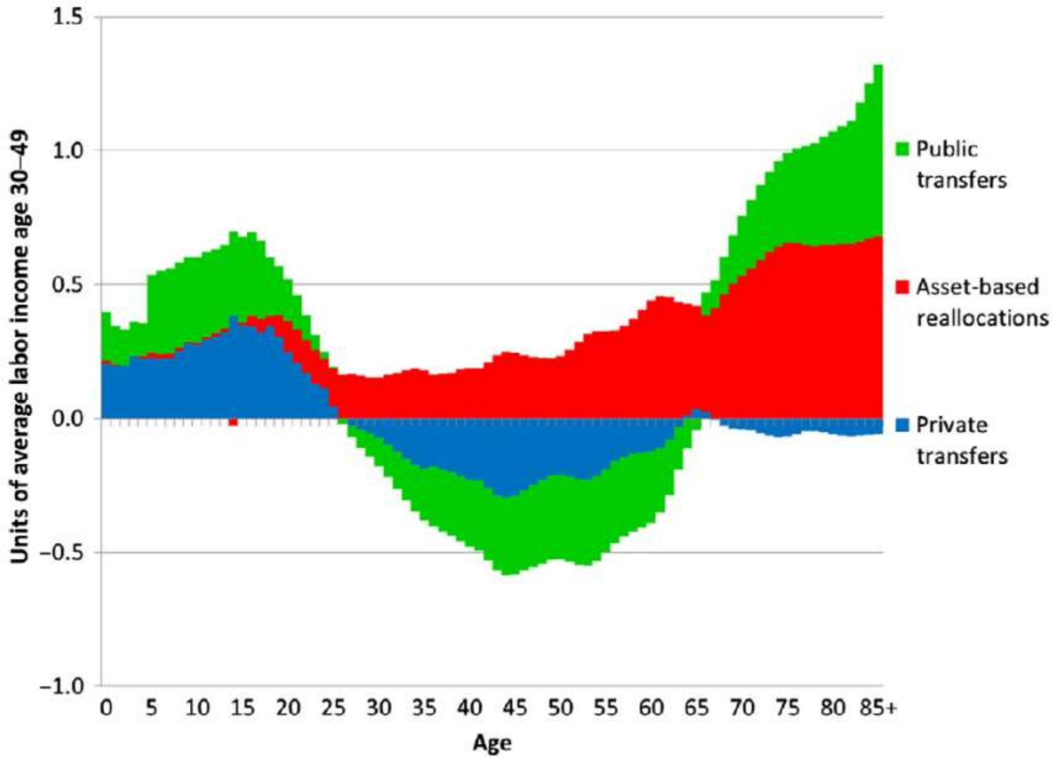

Figure 7: How the gap between consumption and labor income at each age is made up in the United States (NTA data): Components are net public transfers received; net private transfers received; and asset income minus savings (Piggott & Woodland, 2016, p. 70).

The identified strong need in consumption in the last years of life is something relatively new. As fig. 8 here below shows for the United States, the cross-sectional age profile of consumption has evolved since the 1960's. This is also true for other rich nations. The age-related consumption patterns are impacted mainly by two factors, the decisions made by individuals in relation to their retirement planning and by the change in public health and social care policies. The increased relative contribution of the various public health and pension benefits policies initiated across the past decades in the United Stated, is illustrated clearly in fig. 8.

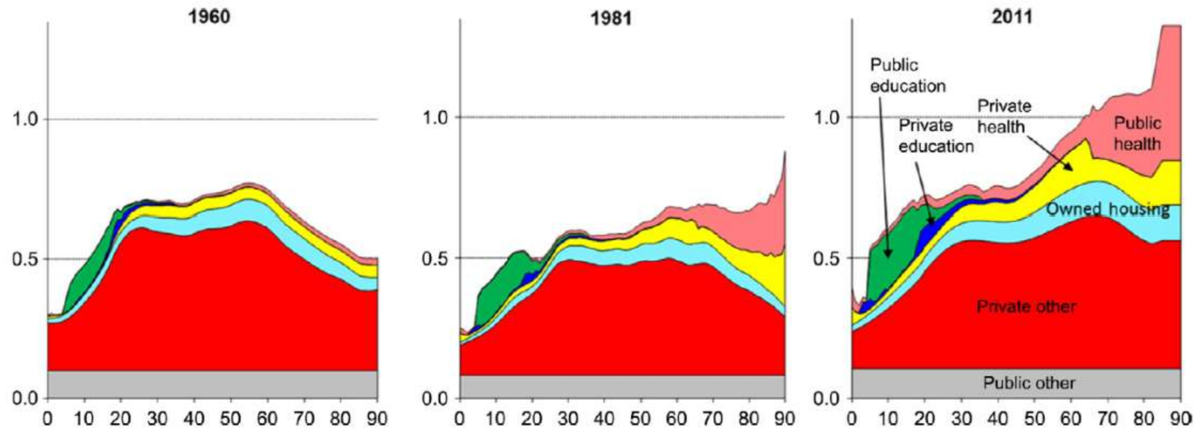

Figure 8: How the cross-sectional consumption age profile has tilted toward older ages over the past 50 years in the United States (NTA) (Piggott & Woodland, 2016, p. 72).

2.2.2 Economic growth and aging

To assess the impact of an aging population on economic growth, one variable, on top of the change in consumption and income patterns discussed above, needs to be integrated, namely capital. A population which is growing slower and is aging is expected to be saving more. The main two reasons for such a forecast are the extension of the retirement period and the increase in insecurity regarding the financing of future retirement pensions. More saving means also less borrowing to sustain consumption and ultimately economic growth. The described negative impact of more saving on economic growth could be limited to a certain extent thanks to the conversion of the savings in profitable investment opportunities. The latter will most likely be found in global areas where a relatively strong economic growth can be supported by robust fundamental macroeconomic parameters, among others, a supportive demographic. The specific areas with a foreseen strong economic development are Asia first and ultimately Africa. In order for the savers and investors in the aging and low population growth countries of the world to benefit from those higher return investments, the economies of both Asia and Africa will need to be integrated in the global economy (Teulings & Baldwin, 2014, pp. 143-146).

2.2.3 Avenues for policy action to curb the adverse economical effects of an aging population

The influence of aging on the economy depends on the portion of older people who continue working, the consumption of the older part of the population, the existence of appropriate public health and pension systems and finally the general health conditions of the elderly. The productivity seems not to be impacted by the aging of a nation. Consequently, the corresponding reforms to support the economy include raising the retirement age, applying public policies increasing the income transfer from the younger generations to the older ones and introducing policies to improve fertility such as supporting parents with children to optimize their employment (Piggott & Woodland, 2016, p. 60).

2.3 Theoretical approach to modelize the impact of aging on residential property prices

The approach carried out is based on one main hypothesis: Changes in the characteristics of a population and its cohorts have an impact on economical aggregate patterns such as income, consumption and saving and how the latter ultimately affect the demand for assets and their price. Multiple research analysis whether theoretical, Yoo (1997) and Brumberg & Modigliani (1954) or empirical, Börsch-Supan (2006), Krueger & Ludwig (2007), Ludwig et al. (2011), Poterba (2001 & 2005), Abel (2001 & 2003) have been conducted on the above theme. If the determined theoretical models tend to hypothesize an impact on the defined equilibrium by a change in the population characteristics, empirical approaches seem not to verify a strong effect of population on the value of assets, whether they are financial assets or real estate. The reasons for the nonsignificant empirical results are manifold. The lack of enough data for time series of demographic variables and those on the return of assets is among them. One other important reason is the introduction of international flows of capital in the empirical analysis, whereas the theoretical approaches tend to be based on a closed economy. The analysis which include import and export of capital tend to show a reduced impact of the population aging on economical variables (Piggott & Woodland, 2016, p. 101). One conclusion, which can clearly be drawn from the literature published in the past four decades, is that the demographic aging transition will most likely not generate an asset meltdown. If aging may have a negative impact on asset prices, including real estate, which is our point of interest here, it will be done gradually. The impact of aging would not be abrupt and therefore the market would forecast it. Even though real estate is an illiquid market, which stock or supply, at least in the midterm, is hardly compressible, a price decrease would be slow.

2.3.1 Model Setup

To implement a theoretical approach associating the life path of individuals and one's relation to an asset such as a residential property, Takáts (2012) has conceptualized an overlapping generation model following Allais (1947), Samuelson (1958) and Diamond (1965). In this model, identical agents go through two periods in life. One is in the young age, where agents generate income through work, of which some is saved to consume in his old age. The utility function (U) of an agent can be written as follows:

$$U = \ln(C_t^Y) + \beta ln(C_{t+1}^O) \qquad (1)$$

Where ln() is the natural logarithm, C^Y is consumption at a young age, C^O is consumption at an old age, β is the discount factor and t & t+1 are two period time parameters.

The agent maximizes his utility according to a resource constraint, namely the income generated at young age, Y^Y, as per the equation (2) here below. The aggregate income corresponds to the size of the economy. The growth of the economy is expressed through its rate, g_t: $Y_{t+1}^Y = (1 + g_t)Y_t^Y$.

$$C_t^Y + \frac{C_{t+1}^O}{1+r_t} \leq Y_t^Y \qquad (2)$$

The discount factor is here established using the interest rate, r, determined on period t: $(1/(1 + r_t))$

To introduce the real estate element in the model, the budget equation can be formulated differently, as seen here below under (3). The consumption on t+1 is replaced by the value in period t of a residential asset. The income of the working generation, y, is split. It is allocated between consumption at a young age (period t) and the acquisition of an asset a of price p:

$$Y_t^Y = C_t^Y + p_t a_t \qquad (3)$$

Takáts (2012) has then formulated the asset at an aggregate level according to the defined equilibrium, where the value of the total amount of assets equals to the total of savings made by the young generation (expressed as $p_t K$) divided by the total population of the young individuals (n_t). Thereby the budget equation (3) can be reformulated as here below (4). The growth of the population is expressed through its rate of growth, d_t: $n_{t+1}^Y = (1 + d_t)n_t^Y$

$$Y_t^Y = C_t^Y + p_t \frac{K}{n_t^Y} \qquad (4)$$

On t+1, the retired population sells their home which value has evolved according to the rate of return (r_t) and the proceed will be consumed:

$$C_{t+1}^{O} = (1 + r_t)\,(p_t \frac{K}{n_t^Y}) \qquad (5)$$

2.3.2 The Solution of the model

The first step that Takáts (2012) took to solve the model is to express the maximization of the utility function by taking it to the limit. To do so, we equate the first derivative of the function to 0, in order words, we determine its first order conditions and derive from it an expression of the consumption of the retired population (C_{t+1}^{O}):

$$C_{t+1}^{O} = \beta(1 + r_t)C_t^Y \qquad (6)$$

We then combine (6) with the budget constraint (2) to express the consumption at a young age:

$$C_t^Y = \frac{Y_t^Y}{1+\beta} \qquad (7)$$

Based on the above, we can rewrite the aggregate equilibrium for the young generation (4) to express the total value of the residential assets, equation (9). We can also apply the same for the next working generation, equation (10), in the following period (t + 1):

$$Y_t^Y\left(1 - \frac{1}{1+\beta}\right) = p_t \frac{K}{n_t^Y} \qquad (9)$$

$$Y_{t+1}^Y\left(1 - \frac{1}{1+\beta}\right) = p_{t+1} \frac{K}{n_{t+1}^Y} \quad (10)$$

To express the effect of the demographic and economic growths on the value of real estate assets between periods, the equation (10) can be restated by introducing the demographic and economic growth elements:

$$Y_t^Y(1 + g_t)\left(1 - \frac{1}{1+\beta}\right) = p_{t+1} \frac{K}{n_t^Y\,(1+d_t)} \qquad (11)$$

The real estate asset price evolution can be expressed in regards with the demographic and economic development by dividing the equation (11) by the equation (9), resulting in the equation (12) here below. The concept behind this equation stipulates that real estate prices will be higher in the next period if the demand for residential properties increases. This would be driven by a population growth and a real exogenous economic growth.

$$\frac{p_{t+1}}{p_t} = (1 + g_t)(1 + d_t) \qquad (12)$$

3. Empirical Analysis

As the above described theoretical economical model remains a conceptual abstraction, the empirical approach deviates someway from it. The main sources of inspiration for the empirical modeling portion of my study are two articles, Takáts (2012) and Tamai et al. (2017). Tamai et al. has applied the broad concept of Takáts, though the empirical analysis is based on a panel of a national data set, namely Japan. They also added a simulation portion to their study to assess the impact of aging on the real estate prices in the next two generations. Both above mentioned articles have used data from several distinctive geographical areas, either countries (22 advanced nations) or municipalities (892) over time. Consequently, they were able to build up a panel of data and perform a panel regression analysis. As mentioned in the above section 2.3, the historical span of data is central to the analysis of the impact of demography on economical matters. Therefore, the set of historical data available, especially in terms of residential real estate prices, was decisive in my choice of empirical model. From 1970 on, Wüest Partner AG ("WP") has constructed, at the country (Switzerland) level, various residential real estate price indices and thus on a quarterly basis. As the scope of my study is geographically limited to one country, Switzerland, the above data constraint does not permit me to perform a panel regression. Since the center of main interests of my study is to discuss the potential impact of the foreseen aging of the Swiss society on residential real estate prices, I selected an alternative econometrical model which has forecasting characteristics. My choice fell on a vector autoregression ("VAR") model. A VAR model applies a stochastic process to analyze time series of multiple variables. As its name implies, VAR is an autoregressive model. It uses, in a regression analysis, the past observations of its variables to predict the values for the next time period.

3.1 Estimated Model

Five explanatory variables have been selected for the VAR analyis. Three correspond to the main economic factors of the above theoric model. They are namely economic growth, population growth and the OADR. Both Takáts (2012) and Tamai et al. (2017) mainly focused on these 3 variables. As I am not using a panel data set, I extended the number of explanatory variables for the regression model to five. I added the volume of real estate investment as variable to capture a real estate supply side factor. Additionally, on the real estate demand factor side, the mortgage rate was included as a supplementary explanatory variable. In the below sections, I first go through the selected variables and I make references to past reasearch publications which have assessed the significance of factors explaining change in house prices. I secondly describe the applied empirical model.

3.1.1 The dependent variable – residential real estate prices

The dependent variable of my regression is understandably residential real estate prices. More specifically, hedonic price indices on three different types of residential real estate properties have been used. Namely price indices on single-family homes, condominiums, and multi-family investment properties. The three different types of property have been progressively implemented according to the date of launch of the respective indices.

3.1.2 The explanatory variable – economic growth

I chose the Swiss annual real GDP ("Gross Domestic Product") as economic growth / income variable. In the literature, economic growth has been broadly identified as a robust explanatory factor of the evolution of house prices. For his analysis of the changes in house prices across 6 developed countries, Sutton (2002) picked GNP ("Gross National Product") to add incomes generated abroad. He identified with his estimates that national income growth has a positive effect on houses prices.

3.1.3 The explanatory variable – population growth

The evolution of the size of the population is fundamental to the main questioning in this study. As mentioned in the above sections, demographers expect the aging phenomenon to have not only a structural impact on the population but to negatively affect at some point the size of the population. Borowiecki (2009) has found in his VAR analysis of the determinants of Swiss house prices and construction that the population growth is the most influent parameter of house prices.

3.1.4 The explanatory variable – OADR

This variable is likewise central to my analysis since it measures the level of aging of a population. On top of Takáts (2012) and Tamai (2017) whose studies are focused on the demographic matters and show that aging has a significant negative impact on house prices, an OADR has been selected by Belke (2017) as independent variable in their study of the fundamental factors to determine house prices in Germany. The results of the latter study shows that on the demand side, at a regional level, the age structure of the population was, beside the size of the real estate market and level of infrastructure, a determining factor of real estate prices.

3.1.5 The explanatory variable – mortgage rate

Sutton (2002) shows that a change in interest rate has a significant negative impact on houses prices. Annett (2005) who analyzed house prices and monetary policy in the Euro area, has obtained across his whole panel significant results regarding the negative effect of interest rate on house prices. Gattini et al. (2010) also found in their study forecasting house prices in the Euro zone that low real estate financing cost was, beside housing demand, significant at explaining the house prices dynamic. We should therefore expect a negative sign for the coefficient of this variable. Belke (2017) has selected the yield rate on 10 year German government bonds as a proxy of the cost of capital. I picked the nominal mortgage rate, more specifically the mortgage rate index on newly financed residential properties which is designed and published by the SNB ("Swiss National Bank"). The mortgage rate is the closest proxy available to the cost of financing for real estate.

3.1.6 The explanatory variable – real estate investment

Adalid & Dedken (2007) show that housing investments are stronger in higher real estate price trends. Gattini et al. (2010) have also obtained significant results regarding the explanatory power of housing investment, as component of the housing supply, for changes in housing prices.

3.2 Data

Depending on the type of data, I have used different sources. The demographic, economic and construction data are derived from the FSO. The data for the real estate prices are indices produced by WP on behalf of the Swiss National Bank ("SNB"). The data are annual. The historical data range spreads from 1975 until 2015. This four decades period covers multiple economic cycles.

I have adjusted the nominal values of the sourced data to real terms, using a GDP deflactor, except for the mortgage rate which remained in nominal terms.

3.2.1 Real estate prices

For two types of residential properties, condominiums and single-family homes, WP has been generating offering price indices from 1970 and transaction price indices from 1985. From 2005 on, WP has introduced price indices for an additional residential property category, multi-family investment properties. For different sub-periods, according to the indications provided by economic researchers of the SNB, I designed a yearly dummy residential property price index composed of the available and most suitable price indices generated by WP for the respective residential property categories. Further below, for each determined sub-period, I describe the basis of design for the weighting of the indices of the different property categories.

For its offerings-based price indices, for the period 1970-1995, WP has designed a differentiated sampling plan and collected for each year a total of about 100’000 offers for real estate items (Wüest Partner AG, undated). The data are sampled in single homogenous groups to generate for each of them an average price. WP has used three available characteristics to define the groups, namely the number of rooms, the macro geographic location and the condition of the building. The averaging was done with median results to subdue outliers. Subsequently, the groups were weighted to compose an overall index. The indices are of the Lowe type, the weightings assigned to the defined groups are using a moving average over 40 quarters. This lapse of time has been arbitrary defined, corresponding to the theorical length of an economic cycle. From 1996 on, WP has amended the method, moving away from a sampling plan to a broad survey base of yearly 500’000 observed offers. Furthermore, the period span for the moving average of the weightings has been shorten to less than 10 years. For the years 1975-1984, only the WP offering price indices for the categories condominium and single-family home are available. The Weightings for condominium (56%) and single-family home (44%) of the real price indices are based on the 1996-2020 average of the weighting of the respective volumes of offers provided by WP.

For the period 1985-2004, also, only the WP offering price indices for the categories condominium and single-family home are available. The Weightings for condominium (65%) and single-family home (35%) of the real price indices are based on the indicative allocation provided by the SNB. For this specific period, the indices used are the transaction indices generated by WP.

For the years 2005-2015, the weightings for the condominium (48%), the single-family home (26%) and the apartment building (26%) real price indices are based on the indicative allocation provided by the SNB. The single property category indices used are the transaction indices generated by WP.

3.2.2 Real estate investment

For this category of data, I have not found a consistent and systematic time series spamming across the assessed period, 1975-2015. Therefore, as described here below, I have bootstrapped different types of data provided by the FSO. For the period prior to 1994, the data used are broadly defined real estate investment figures or estimates.

For the period 1975-1980, I took the rate of change year on year percentage of the real total construction investment. Source: FSO (Schätzung des Bundesamt für Konjunkturfragen, vierteljährliche Schätzung des Bruttoinlandsproduktes).

For the period 1981-1987, I took the rate of change year on year percentage of the real housing construction investment. Source: FSO (Schätzung des Bundesamts für Konjunkturfragen, vierteljährliche Schätzung des Bruttoinlandsproduktes).

For the period 1988-1993, I used the rate of change year on year percentage of the real total construction investment. Source: FSO (GDP construction investment, (national accounts))

For the period 1994-2015, I took the rate of change year on year percentage of the real housing construction investment. Source: FSO.

3.2.3 GDP and GDP deflactor

The annual data for the nominal and the real GDP were sourced from the website of the FSO.

3.2.4 Population

The annual total population data as well as the data for the 2 cohorts of 20-64 years of age and 65 years old and older to build the old age dependency ratio, were sourced from the website of the FSO.

3.2.5 Mortgage rate

The nominal annual data were sourced from the website of the SNB. It corresponds to volume weighted mortgage rate assigned by swiss banks on new financing/refinancing unencumbered from the term of the credit contract.

3.3 Model Assessment

3.3.1 Stationarity

For a VAR model to obtain robust results, the statistical characteristics of its variables should remain as much as possible stable through time. I selected the Augmented Dickey–Fuller test ("ADF") to assess whether a unit root of the data series of each variable was present. For some variables, I could not reject the hypothesis that the unit root was present in the data series, I engaged a detrending process for the corresponding data. The ADF results for the data series and when required their detrended acolytes are shown in Table 1 here below.

Table 1: Unit root testing

Variable		ADF	
Name	**Description**	**Unadjusted**	**Detrended**
PRICE	First difference of real residential estate price	-2.256	-2.256
	(GDP deflated)	(3)	(3)
REVENUE	First difference real GDP	-3.772*	-
		(3)	-
OADR	First Differnce OADR	-4.536***	-
	(age of 65+ and 20-64 years population ratio)	(3)	-
POP	First difference of total population	-2.758	-3.56**
		(3)	(3)
RATE	First difference interest on newly financed	-2.238	-4.454***
	mortgages	(3)	(3)
INVEST	First differnce of real real estate investment	-0.8055	-3.409*
	(GDP deflated)	(3)	(3)

Note: The level of lags is in parentheses. *, **, *** indicate the rejection of a unit root at the 90%, 95% or 99% confidence level.
Source: Proprietary calculation.

According to the above obtained results, I cannot reject the hypothesis of a unit root for the time series of the main endogenous variable, residential real estate prices (PRICE). Additionally, the time series of the second endogenous variable, real estate investment (INVEST), does not indicate a very strong stationarity. And this even after having been detrended.

The two above described results would suggest performing a cointegration test on the endogenous variables. If it would have come out positively conclusive, another model should have been applied instead of a VAR. A vector error correction ("VEC") model would have been more appropriate and more solid. This further analysis step goes beyond the scope of my study.

3.3.2 Selection of the information criterion

Between the Akaike information criterion ("AIC") and the Schwarz Bayesian information criterion ("SC"), I picked the latter. As described by Koehler (1988), both criteria are penalized likelihood criteria though SC tends to penalize complexity more. In view of the relatively high heterogeneity of the characteristics of the selected variables for the model, SC seemed to be more appropriate.

3.3.3 Lag order

A VAR model requires the optimum level of lags to be parametrized. Based on the obtained estimators for the respective information criterion AIC and SC in the below Table 2, I selected a lag order of one. Consequently, the estimated model will be VAR (1).

Table 2: Lag order selection

Information criterion	Lag		
	1	2	3
SC	-7.820	-7.712	-7.604
AIC	-7.912	-7.850	-7.789

Note: The lowest estimation for both information criterion determines the most suitable order of lag.
Source: Proprietary calculation.

3.3.4 The model

The following equation corresponds to the parametrized VAR (1) model and is fitted to the data:

$$\Delta h_t = \beta_1 \Delta h_{t-1} + \beta_2 \Delta r_{t-1} + \beta_3 \Delta o_{t-1} + \beta_4 \Delta t_{t-1} + \beta_5 \Delta m_{t-1} + \beta_6 \Delta i_{t-1} + u_t \quad (13)$$

Where t is a time subscript (year), Δ represents the first difference operator. In terms of the variables, h is the log of real residential real estate prices, r is real GDP, o is the OADR, t is the log of the total population, m is the nominal mortgage rate, i the real real estate investment and u a constant.

3.4 Empirical Results

Prior to describing the obtained results, it is central to put in perspective the outcome of such an empirical exercise, involving demographic and real estate parameters. Brooks (2006) mentions the limited amount of observations, when it comes to assessing times series of demographic data.

Regarding the real estate market, the limited amount of data on prices, the heterogeneity of single properties as well as the low level of reactivity of supply to changes in demand, may contribute to the instability of empirical models.

3.4.1 Model estimation

The first things to note from the estimated coefficients of the variables shown in Table 3 below is that half of them are not significant, namely for GDP, total population and real estate investment. A simple visual comparison of the graphic illustrations for the historical evolution of the real estate prices, fig. 9 here below, with those of the total population, fig. 11 under section 3.5.1 further down, as well as the real GDP, fig. 10 here below, provides a hint of the potential low level of the explanatory power of the latter variables.

Table 3: Model Estimation

Model (Equation 13)		
Variable	**Estimate**	**Standard error**
$\Delta \mathbf{h}_{t-1}$	0.3962***	0.138
$\Delta \mathbf{r}_{t-1}$	7.984e-7	4.788e-7
$\Delta \mathbf{o}_{t-1}$	0.009943**	0.004598
$\Delta \mathbf{t}_{t-1}$	1.498	0.807
$\Delta \mathbf{m}_{t-1}$	(0.01498)***	0.004924
$\Delta \mathbf{i}_{t-1}$	0.001237	0.001013

Note: *, **, *** indicate 10%, 5% and 1% significance levels.
Source: Proprietary calculation

Secondly, the coefficient for OADR, although significant at a 5% level, has a positive sign. This is not in accordance with my main hypothesis, that a relative increase in older cohorts of the population would negatively impact residential house prices. Obviously, in the perspective of Switzerland, an opened economy, where migration of relatively young people has played a substantial role in the population growth over the covered four decades, changes in OADR have not been substantial. Takáts (2012) had performed for the single countries covered a sensitivity analysis on their explanatory variables. For Switzerland, although it had a negative sign, the coefficient for OADR was not significant. Among the obtained results, although not statistically significant for the designed model, a 1% increase in total population would result in a 1.4% increase of the residential real estate prices.

The obtained explanatory power of the model for the variation of real estate prices is 58% (adjusted R2). This result is in line with other published econometric analysis of the swiss residential real estate price market.

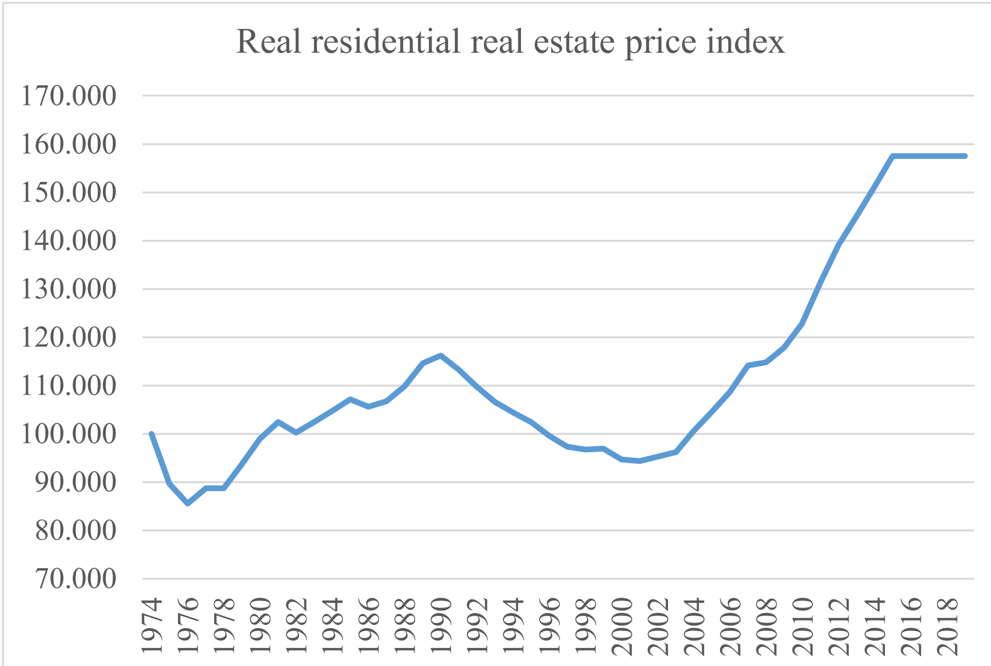

Figure 9: Real residential real estate price index

Source: WP, FSO and proprietary calculation

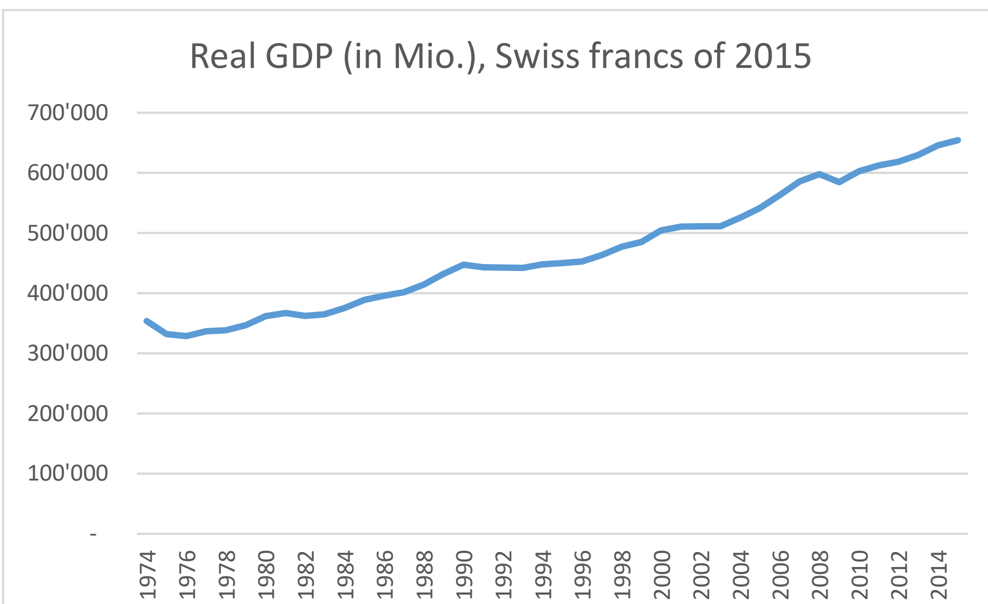

Figure 10: Real GDP (in Mio.)

Source: FSO

3.4.2 Analysis of the error terms

According to the results of the tests obtained in table 4 here below, there is neither correlation nor autocorrelation amon the error terms. Additionally, the calculated p values for the tests in relation to the normality of the distribution of the residuals indicate that the model is white noise.

Table 4: Testing for autocorrelation and distribution

		Chi^2	**df**	**p-value**
Tests for serial correlation of the residuals:	**Portmanteau test**	465.25	540	0.9911
Tests for Heteroscedasticity:	**ARCH test**	735	2205	1
Tests of the normality of the distribution of the residuals:	**Jarque-Bera Test**	7.9423	12	0.7896
	Skewness Test	2.5321	6	0.8637
	Kurtosis Test	5.4002	6	0.4936

Source: Proprietary calculation

3.5 Simulation

I referred to the paper of Takáts (2012) to formulate the theoretical model of overlapping generations. The latter focuses on an empirical analysis though it does not perform any simulation to forecast the effect of aging on residential real estate prices in the coming decades. Other pieces of literature published in the past two decades have performed simulations based on demographic forecasts, Tamai et al. (2017), Yoo (1997), Ludwig (2012), Börsch-Supan (2006), Porterba (2001), Sun (2018) or Guest (2010).

3.5.1 Simulation Approach

I chose to follow the approach taken by Tamai et al. (2017), basing the simulation on the estimated model described in the Table 3 above. I calculated the forecasted real residential real estate prices up to year 2040 feeding the models with assumed values for the different explanatory variables. For each variable, either assumptions of the future growth have been made or the forecasts, made by the FSO for their reference scenario, have been applied. A 0.8% yearly growth of the real GDP has been assumed. It corresponds to the average annual growth spotted between 2005 and 2015. This methodology corresponds to the one adopted by Tamai et al. (2017). The evolution of the OADR and the growth of the total population are based on the demographic forecasts of the FSO. Those predictions have been documented in section 2.4.1 here above. For the mortgage rate, since we have been for the last decade and currently going through a period of experiments in terms of monetary and central banking policies, it is challenging to make sensible predictions. Consequently, I decided to set a stable 1% mortgage rate for the whole forecasted period up to 2040. Regarding real estate investments, I defined a yearly growth path along the one forecasted for real GDP, 0.8% a year.

The historical evolution (blue solid line) and the FSO forecasts (orange solid line) for the total population and the OADR are illustrated in the below fig. 11 and 12 respectively. From the graphic illustration of the total population, we can clearly visualize a mostly smooth and almost linear growth path, historically as well predictively. We can therefore consider that the obtained corresponding coefficient can suit the need of a simulation. The graph for the OADR, fig. 12, depicts a rather more changing rate of growth across time. Especially, a clear change of regime in growth, namely much stronger, can be identified for the whole forecast period. Looking at the time series used to parametrize the estimated model, the latter cannot possibly capture this forecasted evolution in the aging of the population. As a result, the obtained coefficient for OADR is most likely far from its realistic impact on the future residential real estate prices.

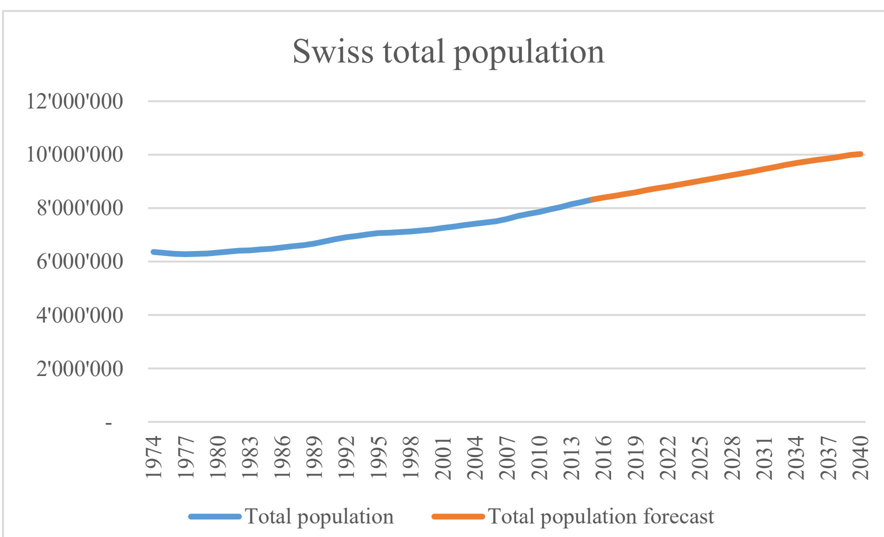

Figure 11: Evolution and forecast of the Swiss total population

Source: FSO and proprietary calculation

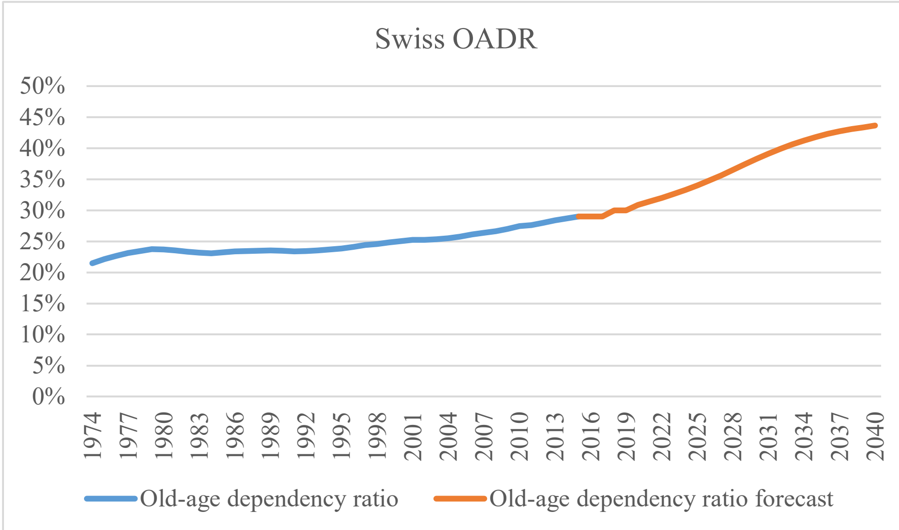

Figure 12: Evolution and forecast of the Swiss OADR

Source: FSO

3.5.2 Simulation results

The simulation needs to be seen not as more as a basis for a discussion on the potential distortion effect of the aging of the population on real estate prices. It is central to stress that any projection beyond one generation sees an exponential increase in projection error Krueger (2007). Additionally, the predictions performed with a VAR model are usually made to forecast policies measure for a short period of time corresponding to a couple of years. The assumptions made above of continuous GDP and construction investments growth as well as stable mortgage rates do clearly have a strong compounding effect over the years. It is not to mention that no shocks are taken in account.

My simulation obtained an annualized 7% growth in real residential real estate prices between 2015 and 2040. In my opinion, this is clearly unrealistic. Immigration plays a key role in sustaining the economic growth of Switzerland. The net migration of flow of active individuals as well as children has so far reached a peak in 2015. In view of the current discussions and the broad opinion in Switzerland on the type of future policies to be applied in terms of the net positive migration flow, it is hard to conceive that the demand for residential real estate will be able to contribute to such a growth of the prices of properties.

4. Conclusion

In this study, I first explored the theoretic aspect of the aging population in demography as well as in economics. I secondly referred to the past corresponding academic studies to model the theoretical economic dynamic of residential real estate investing across generations. Thirdly, I ran an empirical analysis using a VAR model to assess the explanatory power of some economical and demographic variables for residential real estate prices. Finally, I ran a simulation based on the results of the VAR model to forecast the growth of the residential real estate prices in the next two decades. Both the empirical analysis and the simulation did not provide robust results.

The modeling of demographic and economical time series is a challenge and thus for 2 reasons. First, the former has a notorious lack of data. The best periodicity to be obtained is yearly. Consequently, the considered data time series available would ideally span over multiple decades. Secondly, there is a dichotomy between the duration of the shocks and cycles in demographic and macroeconomic terms. At a nation level, meaningful demographic phenomena tend to develop across periods of multiple decades. Their effects then last for even longer periods. Two well documented examples are the baby booming at the beginning of the second half of the 20th century and the accelerating aging of the population in the developed countries which started to be meaningful in the late 1970s. Economical events and cycles haven been comparably much shorter. In the case of the historical period for Switzerland which was studied here, the OADR has seen a relatively slow growth if it is compared with what the FSO predicts for the next 2 decades. We can draw the conclusion that the relation between the OADR and the residential real estate prices could not be properly estimated in the VAR model. Consequently, it cannot be an appropriate tool to perform a simulation for the next two decades.

A further step to be taken to progress in the topic of this study for Switzerland would be perhaps to collect data at a regional level such as cantons. These data would form a panel of data and thereby it would enable a panel regression analysis. The demographic disparities across cantons may provide better estimates for the coefficients of the corresponding explanatory variables.

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Declaration of Authorship

I hereby affirm that I have written the presented thesis on the topic *"A 2040 projection of Switzerland's residential prices"* without any further auxiliary means than the ones cited in this thesis. Every part of this thesis has been cited literally or analogously from published or unpublished writings by clearly indicating in every single case its source (including secondary literature).
This thesis has not been submitted in this or any similar form to any other examination committee and has not been published so far.

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