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Demographic change in Switzerland: Impacts on economic growth in an Overlapping Generations Model

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Abstract

This paper analyses the macroeconomic implications of a future shift in the age structure of the Swiss population. It estimates the long-run effects for Swiss GDP growth and its components in an Overlapping Generations Model (OLG model). Recent population projections by the Federal Statistical Office (FSO) serve as a basis. To document the sensitivity of the results with respect to the demographic assumptions, simulations were undertaken for a range of alternative scenarios concerning fertility, migration and age-specific labor supply. Our projections over the time horizon 2018-2060 document a significant loss in terms of economic growth in both absolute and per capita terms. According to our simulations, this would primarily affect the income of the middle-aged age groups. Likewise, the process of ageing would have consequences for the composition of Swiss GDP: the share of government spending on domestic value added is simulated to increase, due to its demography-related components. A sensitivity analysis reveals that more favourable assumptions concerning future net immigration, fertility and labor market participation could mitigate, but not fully compensate these trends.

JEL codes

J11, C68, E37

Keywords

Ageing, OLG-models, Long-term GDP forecasts, Switzerland

1 | Introduction

Demographic ageing processes have become fundamental characteristics of advanced economies. Diminishing birth rates as expression of changing lifestyles are not only a limiting factor to total population growth, but lead in combination with a growing life expectancy also to an increase in the average age. Consequently, the old age dependency ratio, i.e. the ratio of the number of people aged above 65 years to those between 15 and 64 years, is about to increase. In the long-term, this can become a potential heavy burden for the macroeconomic performance of those countries. A lower labor force participation implies a smaller potential GDP growth in per capita terms. At the same time, distributive pressures are likely to increase, as a smaller amount of workers has to cater for an ever growing number of economic dependents. The dimension of this problem however differs from country to country. This is already apparent by comparing demographic statistics within Europe. According to World Bank figures, the average number of births per women ranged in 2017 from 1.34 (Italy, Spain) to 1.92 (France) (WDI, 2019). Due to this diversity, quantifying the economic impacts of ageing requires country-specific demographic projections.

In this regard, the data situation for Switzerland is especially promising. The Swiss Federal Statistical Office (FSO) provides a range of long-term projections regarding the future age structure of the Swiss population and workforce. The consequences of different assumptions concerning fertility, net immigration and labor market participation are revealed by means of a number of alternative scenarios. This allows studying the economic implications of variations in different impact factors. Moreover, Switzerland also represents an interesting case from an economic point of view, with its combination of a comparatively low birth rate (1.54 in 2017; WDI (2019)) and stable positive net immigration.

In this study, we analyze the macroeconomic impact of the existing demographic scenarios by integrating them as exogenous input factors into an Overlapping Generations (OLG) Model and calibrating the model to replicate the Swiss economy. In doing so, the three demographic main scenarios (reference, high, low) published by the FSO are compared with an artificial benchmark with unchanged age structure. Moreover, a selection of alternative scenarios is simulated, capturing variations in fertility rates, net immigration levels and labor force participation. Simulations are carried out as annual projections until the year 2060. In this way, an overview on potential long-term consequences of ageing for the Swiss economy under different demographic paths is obtained. To the best of our knowledge, such an attempt has not yet been made with the current projections for Switzerland.

The study is structured as follows: Section 2 gives an overview on the potential impact channels through which ageing can influence the economy. Section 3 explains the structure of our model and the data used for parameterization. Section 4 discusses the nature of the underlying population projections. Section 5 explains simulation results for the main scenarios, section 6 those of the sensitivity analysis. Section 7 concludes.

2 | Literature

Recent empirical studies indicate that the net effect of demographic change on per-capita-growth of GDP is negative (Bloom et al., 2010; Choi & Shin, 2015; Van der Gaag & de Beer, 2015). The economic literature has identified several channels through which ageing can affect the growth path of an economy. These include all factor markets and entails an impetus for structural change in the final goods sector (Börsch-Supan, 2004). One important channel is the intergenerational transfer taking place through social security systems. This primarily concerns the statutory pension systems. In a pay-as-you-go pension system a growing imbalance between contributors and recipients entails financial bottlenecks that, in absence of subsidization, lead to higher contribution payments and/or smaller claims. Higher obligatory payments impair the purchasing power of the young generation and can reduce work incentives (Börsch-Supan, 2004). Moreover, as health expenditures per capita tend to be higher for older age groups, public health insurance systems are likewise affected, implying an additional net burden for younger age groups.

Furthermore, voluntary forms of intragenerational exchange can be influenced by ageing, through its impacts on individual savings decisions. In general, economic theory suggests that savings incentives should decrease with increasing age, if bequest motives are not dominant. A higher share of elderly could thus reduce the economy-wide savings quota (Aksoy et al., 2015; Börsch-Supan et al., 2006). However, the prospect of an increased life expectancy can also stimulate savings among the younger, as the needs to make provisions for the out-of-work period at the end of life increase (Chen & Lau, 2016). The net effect is thus not a priori clear and can differ between countries and periods.

For capital demand, the consequences are likewise ambiguous. On the one hand, a shrinking labor force potential should depress capital productivity and thereby investment activities (Aiyar & Ebeke, 2016; Aksoy et al., 2015). On the other hand, reduced labor supply can drive up wages, which creates incentives to replace labor by capital and thus stimulates investments (Börsch-Supan, 2004; Lee, 2016).

Complexity is added by the fact that ageing does not necessarily bring about a one-to-one decline in labor supply. Scarcity-induced wage increases can raise work incentives among the young. At the same time, an increase in average age within the working population can have repercussions on average work efficiency. On the one hand, older workers exhibit more work experience, which positively contributes to efficiency (Disney, 1996). On the other hand, both physical power and the up-to-datedness of accumulated knowledge decline at a certain age (Cardoso et al., 2011 Ludwig et al., 2012). Against this background, empirical studies have in various cases identified an inverse-quadratic relationship between age and productivity (Cardoso et al., 2011; Feyrer, 2007; Göbel & Zwick, 2009).To address the conjunction of these effects in a common macroeconomic framework, OLG-Models in the spirit of Auerbach & Kotlikoff (1987) have often been applied (e.g. Chen & Lau, 2016; Choi & Shin, 2015; Curtis et al., 2015; Krueger & Ludwig, 2007; Lisenkova et al., 2013; Ludwig et al., 2012; Nishiyama, 2015). By calibrating model parameters to reproduce the real-life situation in a certain country, the impact of future demographic shocks can be analyzed in the form of simulation exercises. For this purpose, an advantage of the OLG structure is that it allows to explicitly model specific shifts in the age structure. Moreover, it captures the influence of those shifts on consumption patterns through life cycle decision-making.

Uncertainty concerning individual life spans can be incorporated by means of age-specific survival rates, as suggested by Börsch-Supan et al. (2006). Nishiyama (2015) uses such a model setup to analyze the implications of demographic change for private and public expenditures in the USA. Lisenkova et al. (2013) use a similar OLG approach for examining the impact of ageing on growth and composition of the Scottish GDP. Regarding public expenditures, they differentiate between demographic and non-demographic expenditures. For the former category, they assume that per-capita-expenditures grow exogenously with the general rate of technological progress. In turn, public expenditures and public revenues are linked by means of a governmental budget constraint, with tax rates adjusting endogenously. In this way, expenditure increases induced by shifts in the age structure affect tax rates and thus the purchasing power of private households.

In what follows, we will construct an OLG model for the Swiss economy that incorporates all of the features discussed above. In turn, the model will be used to undertake macroeconomic projections based on different demographic scenarios for Switzerland.

3 | Method and data

3.1 | Model structure

The chosen simulation model is a dynamic equilibrium model with an Overlapping Generations Structure (OLG). The age groups are categorized based on five-year intervals (0-4 years, 5-9 years, …, 25-29 years etc.). By assuming a theoretical maximum age of 104 years, this creates a set of 21 age groups. Both demographic and economic model parameters are chosen to reproduce the real-life situation in the base year 2017. Changes in the age structure of the Swiss population over time are reflected by corresponding changes in the number of members of these age groups. Their economic consequences can be interpreted as period-specific shocks, which trigger adjustment processes towards a new long-term equilibrium of the Swiss economy beyond the horizon of the population projections. In what follows, we describe the major components of the model.

Concerning production, the model is simplified to a standard neoclassical one-sector economy. The homogeneous good, being used both as consumption and capital good, is produced by means of three factors of production: On the upper level, a distinction between physical capital and labor is made. These factors of production are aggregated in a two-tier Constant Elasticity of Substitution (CES) production function. On the lower level, total labor is split into a high-skilled and a low-skilled part, in order to reflect potential impacts of ageing on the skill structure of the workforce. Following a standard Ramsey approach

(Ramsey, 1928), the economy-wide technology level is reflected by a parameter, which is assumed to grow exogenously over time at a fixed rate. Hence, we explicitly refrain from modelling any potential linkage between demographic change and innovation[1]. Factor demand is determined by the profit-maximizing decision of a representative firm, equaling factor prices with marginal productivities. Regarding international capital transfers, Switzerland is modelled as a small open economy, the rate of interest is therefore exogenous.

Markets for high-skilled and low-skilled labor are segmented and feature own equilibrium wages. Supply of both types of labor is age-specific. The general employment potential, here interpreted as the labor force participation rate at a given wage level, differs by age group. Moreover, members of different age groups differ in their level of work experience, their average amount of working hours as well as in their age-specific efficiency. All of these aspects influence the production potential and should therefore be considered in modelling. Following Lisenkova et al. (2013), this is implemented in the form of efficiency units. An age-specific efficiency parameter parametrizes individual work efficiency of the different age groups. In doing so, a potential sensitivity of labor supply towards the evolution of wages is considered by adding a wage elasticity parameter, obtained by considering utility from leisure as part of the households' preferences (see next paragraph). In this way, the production potential of labor is not purely determined by aggregate employment, but also by the distribution of workers across age groups and skill segments. At the same time, the segmentation into high- and low-skilled labor is exogenous, i.e. educational investments are not endogenously modelled, but adopted exogenously from the demographic scenarios.

The consumption and savings decisions are treated endogenously in the model. Private households maximize their intertemporal utility over their expected life time. Single generations are modelled as representative individuals. Existing uncertainty regarding the individual life expectancy is explicitly modelled by means of (time-dependent) survival rates, following Börsch-Supan et al. (2006). In this way, changes in general life expectancy immediately affect consumption and savings decisions. Moreover, work-leisure decisions in the form of (skill-specific) penalty terms for the amount of labor supply are accounted for, in order to model endogenous responses to wage changes. Apart from this, the intertemporal utility function of a member of generation g in time period t has a standard form, featuring additive separability and intertemporal discounting:

$$U_{t;g} = \sum_{i=t}^{t+T-g} \left(\prod_{t}^{i} \pi_{i;g+i-t} \right) \cdot \beta^{i-t} \left(\frac{{c_{i;g+i-t}}^{1-\mu}}{1-\mu} - v_{i;g+i-t}^{l} \frac{{l_{i;g+i-t}}^{1+\varphi}}{1+\varphi} - v_{i;g+i-t}^{h} \frac{{h_{i;g+i-t}}^{1+\varphi}}{1+\varphi} \right)$$

with π denoting the survival rate, β the discount factor of future consumption, c the (period- and generation-specific) consumption level, l the supply of unskilled labor, h the supply of skilled labor, μ the inverse of the intertemporal elasticity of substitution and φ the inverse of the wage elasticity.

[1] While there is some evidence for the existence of such a channel at the micro level (Mahlberg et al.), its economy-wide relevance and potential magnitude is in our view too uncertain to quantify it in a macroeconomic model.

As income sources, households obtain besides factor income also age-specific transfer payments. Moreover, they are linked with the public sector by paying taxes and duties, which are summarized in the simplest form by means of a single linear tax. Borrowing is assumed to be free of credit constraints:

$$\sum_{i=t}^{t+T-g}\left(\left(\prod_{t}^{i}\pi_{i;g+i-t}\right)\cdot\left(\frac{\varepsilon_{g+i-t}^{l}(1-tax_i)w_i^l l_{i;g+i-t}+\varepsilon_{g+i-t}^{h}(1-tax_i)w_i^h h_{i;g+i-t}+\left(trans_{i;g}-OKP_i\right)\cdot pop_{i;g}}{(1+(1-tax_i)r)^{i-t}}\right)\right)$$
$$+(1+(1-tax_i)r)k_{t;g}=\sum_{i=t}^{t+T-g}\left(\prod_{t}^{i}\pi_{i;g+i-t}\right)\cdot\frac{c_i^{g+i-t}}{(1+(1-tax_i)r)^{i-t}}$$

with ε_g^l and ε_g^h denoting the efficiency levels for skilled and unskilled labor of a member of generation g, the corresponding wage rates in period t, tax_t the tax rate, $trans_g$per-capita transfers to generation g, OKP_t the (lump-sum) payments to the OKP (explanation see below), $pop_{t;g}$ population size of generation g in t and r the (exogenous) interest rate. Generation-specific labor supply is aggregated to total labor supply:

$$L_t=\sum_{g=1}^{T}\varepsilon_g^l\cdot l_{t;g}$$

$$H_t=\sum_{g=1}^{T}\varepsilon_g^h\cdot h_{t;g}$$

Our model defines the public sector following the definition of the Swiss Statistics, as a sum of federation, cantons, municipalities and social securities. Regarding social securities, it is important to keep in mind the particularity of the so-called Swiss three-pillar system of old-age insurance. Only the first pillar counts towards the public sector in official statistics, which is the mandatory Old-age, Survivors' and Invalidity Insurance (AHV) based on the apportionment principle (FSO, 2003). In contrast, the other two pillars are capital-covered (BSV, 2019). Therefore, they represent individual capital accumulation, even though partly mandatory. Keeping this in mind, it seems reasonable to us to follow the approach of the official statistics and only count the first pillar towards the public sector, and therefore the public budget constraint, in our model. The other two pillars are only considered implicitly and summarized as a component of individual savings and part of the individual consumer’s choice. Another argument for this approach is the fact that the entitlements from the second and third pillar are much more driven by individual contributions than the entitlements from the first pillar. Considering the health expenditure (including nursing care), it is important to differentiate between the various sources in the Swiss system. Official statistics differentiate between the expenditures of the public sector (the mandatory health and nursing care insurance (OKP) as well as other public and social transfer sources) and private sources (including non-mandatory additional insurance and individual expenditure as well as the mandatory personal contributions to treatment cost). In our model, we expand the definition of the public sector and include the mandatory OKP as well as health-related expenditure from other social insurance. The logic behind this is that contributions to these insurances are mandatory and therefore do not belong to the realm of individual decision-making. Furthermore, regarding future premiums for the OKP a strong impact of demography is expected, which requires explicit modeling.

We do not model tax and insurance of Switzerland in detail, but we display the fundamental impact of (financial) burden and discharge on the public budget constraint. The public sector has an impact on both supply and demand of the economy. Public spending on the one hand includes the public demand for goods and services which have a direct impact on demand. We distinguish between exogenous and endogenous components regarding the demographic development. We define health, education and public transfers as expenditures dependent on ageing. The development of those expenditures is derived from the age structure, more precisely from the differences in per-capita expenditures among age groups. We split up public expenditures into the components health, education and transfers and calculate the per-capita expenditures for different age groups. The expenditures for education are furthermore subdivided by school levels. The per-capita expenditures for different age groups are perpetuated with the total factor productivity. The components independent of demographical change are perpetuated proportionally to the development of the value added, including the net debt uptake.

Public revenues adjust endogenously so that the public budget constraint is fulfilled. We use an endogenous tax rate in form of a flat tax (constant marginal tax) on income resulting from factors of production. Thus, a possible effect of demographic adjustments on income taxes and therefore the purchasing power of consumers is considered in the model. The tax rate includes all fiscal revenues from official statistics except taxes on production and imports (indirect taxes). The latter are perpetuated proportionally with the development of gross value added. We also do not include the premia of the OKP because they do not depend on income and are in general calculated uniformly, an inclusion into the tax rate would thus not be suitable. Instead, we model it in the form of a lump-sum duty that has to be paid by each individual and in sum covers all expenses of the OKP. We assume that the share of these expenditures on total health expenditures stays constant over time, assuming maintenance of the regulatory status quo. Rising health expenditure is therefore reflected in higher premium payments, which has a negative impact on private consumption. There is also an interaction between government funding and production through the wage elasticity of the job offer, but only regarding the tax rate. Its increase reduces net wages and thus has a negative effect on the incentive to work. Finally, the composition of the non-fiscal revenue of the state is not explicitly modeled, but is instead perpetuated with the development of the GDP. In all, the public budget looks as follows:

$$taxgood_t + tax_t \cdot \left(w_t^l L_t + w_t^h H_t + r \sum_{g=1}^{T} k_{t;g} \right) + \sum_{g=1}^{T} pop_{t;g}\, OKP_t + Rev_t^{res} + Netdebt_t = Exp_t^{educ} + Exp_t^{health} + Exp_t^{trans} + Exp_t^{res}$$

with $taxgood_t$ representing revenues from indirect taxes in t, $k_{t;g}$ the capital stock owned by generation g in t, $pop_{t;g}$ population size of generation g in t, Rev_t^{res} non-fiscal revenues, $Netdebt_t$ the public net debt uptake. The terms on the right-hand side are the public expenditures split into the categories education ($educ$), health ($health$), transfers ($trans$) and the remaining part (res).

3.2 | Data and calibration

As much as possible, model parameters were calibrated based on publicly available data (see Table A1 in the Appendix for an overview on data sources). In those cases were no appropriate data was available or calibration is technically infeasible, values were determined based on empirical estimations from the literature.

Demographic characteristics, i.e. the evolution of population in the single age groups, are directly adopted from the population projections of the FSO, which are available over the same spectrum of age-groups that is applied in our model (FSO, 2015a). The same holds for projections of age-specific labor force participation rates (FSO, 2015b). The exogenous rate of technological progress (or TFP-growth) was estimated by means of a standard growth accounting procedure (Barro & Sala-i-Martin, 2004), using annual time series data on the Swiss non-financial capital stock from Kamps (2006) and the FSO and on labor volumes from the FSO. Before that, the GDP series was smoothed by implementing a Hodrick & Prescott filter (1997) with a smoothing parameter λ=6,25 (Ravn & Uhlig, 2002). Averages of the resulting growth residuals were calculated over time horizons of the last 10, 20 and 30 years. The lowest average was obtained for the ten-year-period (0.65%), this was adopted as a conservative assumption for future annual TFP growth. Shift-share parameters in the production function are determined as part of the calibration procedure. The elasticity of substitution between high- and low-skilled labor is specified as 0.6, based on a result of Borjas et al. (2011).

Skill levels are separated based on the formal level of education, with high-skilled workers defined as those with tertiary level of education (according to the ISCED-classification). Corresponding numbers were taken from Swiss labor market statistics. To estimate the effective (i,e. efficiency-adjusted) labor supply differentiated by skill level and age group, different data sources had to be combined. First, data from the Swiss Labor Force Survey was used to estimate the shares of economy-wide labor income assigned to high- and low-skilled labor, respectively. Then, the distribution of skill-specific labor income among age groups was approximated by combining data on the distribution of educational level by age from Swiss educational statistics with age-specific household income from the Swiss household survey. The form of this distribution is shaped both by differences in the average amount of working hours and in hourly wages between the age groups. By putting the estimated income levels in relation to the amount of working hours, the age-specific efficiency parameter is calibrated. In line with literature findings (Cardoso et al., 2011; Feyrer, 2007; Göbel & Zwick, 2009), it takes an inversely U-shaped form.

While the evolution of labor force participation rates (i.e. the extensive labor supply) is exogenously determined by the used FSO-scenarios, the model allows for endogenous adjustments of work volumes per worker (i.e. the intensive labor supply) to wage changes. The corresponding wage-elasticity of labor is for both high- and low-skilled work set to 0.05, following recent empirical estimations by Martinez et al. (2018) for Switzerland. Repercussions on labor supply are thus only of a very limited nature. The consumer's intertemporal elasticity of substitution is specified as 0.5, following a meta-analysis by Havranek et al. (2015). On this basis, the annual rate of time preference was calibrated to a level of 0.002. Finally, data on the evolution of the Swiss non-financial capital stock is adopted from FSO-estimations; the depreciation rate is calibrated to a level of 0.135.

Swiss financial statistics are the basis for the adjustment of the model elements relating to the public sector. There are two ways of classifying expenditure, the COFOG and the GFS Method. Since the COFOG classification allows for a more detailed breakdown of education expenditures, which we need for the approximation of age-specific educational expenditure, this classification is more suitable for our purposes.

Three data sources are used to approximate **public expenditure on education** by age group: school attendance rates by age (2017/2018) for ages 3 to 30 for different types of schools, permanent resident population on December 31th 2017 (by individual year and not by age category) as well as public education expenditure by education level, type of expenditure and administrative level for 2016.[2] To calculate the number of pupils by school category and age, the school attendance rates by school category are multiplied by the permanent resident population in the respective age category. Unfortunately, in terms of categories, public spending on education does not match school attendance rates. The categories are therefore summarized as follows: The costs for compulsory school include the costs for compulsory school and special school. For secondary level II, the costs for basic vocational training and general education schools are combined, while the tertiary level includes costs for universities and research as well as for higher vocational training. Expenditures that cannot be broken down are distributed between all students. Since the number of pupils by age of a type of school is known, the cost of attending school can be approximated. For all school categories, the number of students is multiplied by the cost per student. By dividing this total cost of attending school by age category by the number of people (not students) in the respective age category, one gets the total cost of attending school per person in the respective age category. The age structure of expenditure determined in this way is retained for the future. However, keeping expenditure at an absolute level would be unrealistic, since value added in the education sector should also participate in technology-driven macroeconomic growth in the medium term. Therefore, the per capita expenditure within the age groups is updated at the annual rate of technical progress (TFP growth).

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[2] Ständige Wohnbevölkerung nach Alter, Geschlecht und Staatsangehörigkeitskategorie, am 31.12.2017 Öffentliche Bildungsausgaben nach Bildungsstufe, Ausgabenart und Verwaltungsebene, 2016 Schüler/innen und Studierende: Schulbesuchsquoten nach Alter, 2014/15

Furthermore, the distribution of **public health expenditure** by age group must be approximated. On the one hand, a distribution of overall health expenditure by age group for 2016 is available as a data basis (FSO). On the other hand, the total annual costs of the Swiss health care system are recorded in the official statistics and broken down according to the five sources of funding: the state, OKP, other social security / public finance, private insurance and self-payment. We assign the first three sources to the general government sector according to our expanded model-internal definition. According to provisional estimates by the FSO, these financed a share of around 60% of total health costs in 2017. The dominant share is allocated to the OKP (approx. 36% of the total costs). In absence of other information, it is assumed that the age-related distribution of expenditure per person is homogeneous among private and public expenditures. This way, we approximate public health expenditure per capita by age group. Regarding the future development, we assume an increase proportionally to TFP growth, analogous to the expenditure on education. We therefore implicitly assume that the share of financing which is public will remain constant, meaning that public expenditure develops in proportion to total expenditure on health.

The total amount of **government transfer payments** is derived from the category "social security" in the statistics on government expenditures. In addition to payments from the AHV, this also includes support payments to families, the unemployed and other people in need. Data on household income by age group is used to split payments by age category. One problem here is that the data does not include transfer by age category for individuals, but only for households. However, we know the number of persons in a household per age category of the reference person. We assume that on average all employed people in a household belong to the same age category. Therefore, we can calculate approximated pensions and social benefits per person by age group by dividing the transfer benefits of a household in an age group by the average number of people in a household in this age group. For the future distribution of per capita transfers by age group, it is assumed that the status quo will be maintained and no structural adjustment on the expenditure side will be executed. This implies that a future increase in spending will be only absorbed by an adjustment of taxes. The absolute amount of age-specific per capita expenditure is not assumed to be constant over time, but will be perpetuated proportionally to the development of the technology level. This assumes that the extent of social benefits depends on the development of general living standards.

On the income side, taxes and duties must be adjusted to the income of the production factors labor and capital. The tax system is not modeled in detail, in order to keep the model solvable and comparable to other macroeconomic model approaches. Instead, an endogenous constant marginal tax rate is assumed. Its variation over time reflects changes in the fiscal burden on consumers which are caused by shifts in public expenditure. It is calibrated using the ratio of fiscal income to factor income.

4 | Demographic projections

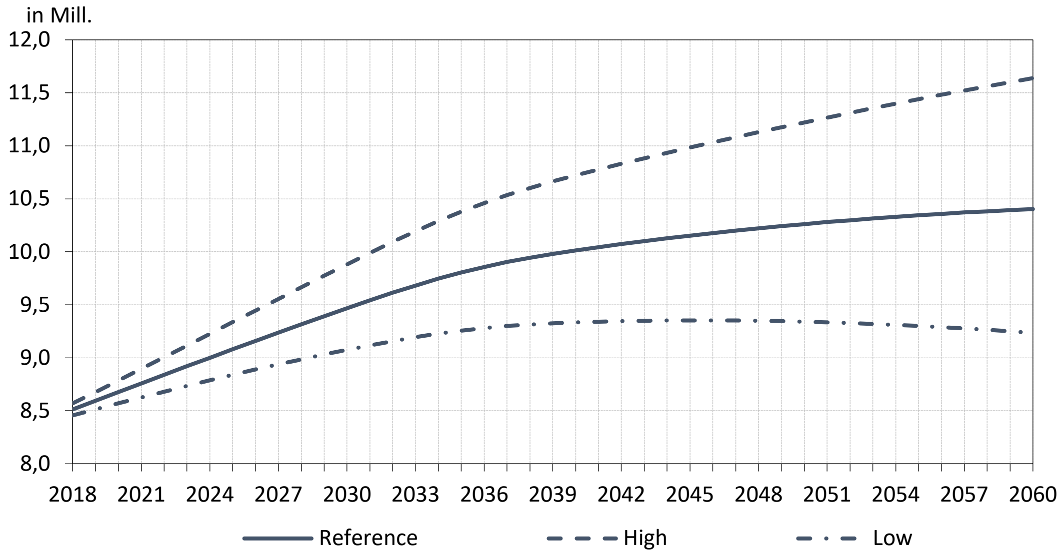
The projections undertaken by the FSO describe alternative development paths for the Swiss population until 2065, derived from specific assumptions regarding fertility, mortality and net immigration (FSO, 2015a). The three main scenarios comprise a scenario „reference" (A-00-2015), which perpetuates the population trends of the past years into the future, a scenario "high" (B-00-2015) based on more optimistic assumptions and a scenario "low" (C-00-2015) based on more pessimistic assumption concerning future population growth. All three scenarios are characterized by a continuous decline in population growth, however at a different pace (see Figure 1). While in the scenario "high" annual growth remains clearly positive throughout the projection period, in the scenario "low" it turns negative in the 2040s. All scenarios expect a steep decline for the crude fertility rate in the early years and a subsequent stabilization until 2040. Concerning net immigration, a similar decline is expected in the 2030s, due to an improvement in the economic situation of the countries of origin.

The resulting increase in the age-dependency ratio is significant. In the scenario "reference" it rises from 28 % in 2017 to 53 % in 2065, in the scenario "high" to 52 % and in the scenario "low" to 54 %. These changes also have direct repercussions on labor force participation, as employment propensities will remain to be lower among older age segments. Consequently, the economy-wide participation rates steadily fall in all three main scenarios.

In addition, several alternative scenarios have been specified by the FSO, which reflect the impact of alternative developments with respect to specific influencing factors. Some of them will be used by us for a sensitivity analysis of our findings. The scenario "high net immigration" (A-06) assumes consistently higher levels of net immigration compared to the main scenarios, without however changing its dynamic pattern over time. As a side effect of intensified immigration, a more favourable development of fertility rates is expected. By contrast, the scenario "improved compatibility of work and family life" (A-09) assumes the same population development as the scenario "reference", but a different evolution of age-specific labor force participation. The scenario assumes that due to improvements in the regulatory environment and/or firm organization a sensible increase in the participation rates of young and medium-aged women will be induced. The scenario "enhanced labor force participation of the elderly" (A-11) is likewise focused on labor market participation, but in this case on participation of the old-age segment. For workers in the age group 60-69, an increase in the employment propensity is projected. The underlying assumption is that the share of workers that retire prematurely will be on the decline in the future (FSO, 2015b).

Figure 1

Population size



Source: FSO (2015a).

5 | Results

5.1 | GDP and components

Table 1 presents simulation results for Swiss GDP growth in absolute and per capita terms. In the scenario „reference“, total GDP growth between 2018 and 2060 amounts to 65.4 %, which corresponds to an average annual growth rate of about 1.2 %. In the scenario „high“, total growth equals 83.5 % (annual average: 1.4 %), compared to only 48.1 % in the scenario „low“ (annual average: 0.9 %). However, these discrepancies are mostly due to differences in total population growth, as a comparison in per capita terms reveal. Per capita GDP is almost identical among the scenarios. At the same time, the predicted changes in the age structure of the Swiss population do have a sizable impact on per capita GDP growth. This becomes clear by comparing results for the synthetic benchmark ("unchanged age structure") with the three main scenarios. Annual GDP growth is simulated to be higher in the benchmark over the whole projection horizon. In our model, this is mainly caused by two impact channels. First, the ageing process induces a reduction in the economy-wide labor force participation rate. While the FSO main scenarios do expect some increase in labor force participation within older age segments, it will continue to be the case that participation rates drop at some point with increasing age, especially when the official retirement age is reached. Hence, the expected shift in age structure impairs aggregate participation. Second, based on our approach of estimating age-specific efficiency profiles, an increase in the share of older workers also entails a negative efficiency effect. At the same time, endogeneity of labor supply merely plays a minor role, due to the low wage elasticity.

As a result, the relative gap in GDP between synthetic benchmark and reference scenario reaches a level of 19.1 % at the end of the projection horizon. Regarding Per-Capita-GDP, this gap amounts to 18.8 %. However, this development does not occur linearly over time. In general, growth of absolute GDP is projected to flatten over time in all considered scenarios, mainly as a consequence of reduced total population growth. For Per-Capita-GDP, the time pattern is more complex. This is a consequence of the idiosyncratic age dynamics. Initially, growth rates are on the decline, caused by the substantial increase in the age quotient until 2030. Then, these dynamics are reversed by the gradual decease of the „baby boomer" generations born in the 1950s/60s, which causes the positive impact of technological progress to dominate growth rates. In the 2040s, growth is again weakened by a new boost to ageing, this time resulting mainly from an expected decline in mortality rates. In turn, this process is completed in the late 2050s.

Table 1

Annual real GDP growth in % (5-year averages)

Scenario	2018-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2051-2055	2056-2060
Absolute								
Benchmark	2.08%	1.99%	1.87%	1.59%	1.42%	1.34%	1.25%	1.19%
Main scenarios								
Reference	1.57%	1.36%	1.34%	1.17%	1.09%	1.02%	0.96%	0.97%
High	1.88%	1.67%	1.63%	1.41%	1.31%	1.24%	1.16%	1.16%
Low	1.24%	1.03%	1.03%	0.92%	0.87%	0.80%	0.73%	0.76%
Per capita								
Benchmark	1.14%	1.14%	1.16%	1.16%	1.15%	1.12%	1.09%	1.07%
Main scenarios								
Reference	0.63%	0.52%	0.64%	0.75%	0.81%	0.81%	0.80%	0.86%
High	0.64%	0.52%	0.64%	0.76%	0.82%	0.81%	0.77%	0.81%
Low	0.61%	0.50%	0.63%	0.75%	0.83%	0.82%	0.82%	0.90%

Source: own calculations

At the same time, our simulation results show that the shift in the age structure can influence the composition of the Swiss GDP on the demand side. Table A2 in the Appendix documents growth rates for different expenditure categories. In all main scenarios, the share of private consumption in GDP declines slightly over time, with increasing intensity from the 2030s onwards. This is the product of two opposing effects. On the one hand, consumption is supported by the fact that older age segments make up an increasing share in the total population, as their personal savings incentives are low. On the other hand, an increase in life expectancy stimulates savings, which is reflected by the survival rate in our model. This latter effect slightly dominates the development. It does so in an increasing manner, as ageing dynamics are reduced. Similarly, growth of gross fixed investments is weakened both in absolute terms and relative to total GDP in all main scenarios. This is a direct consequence of the subdued dynamics in labor supply and their negative impact on capital productivity, undermining investment incentives.

By contrast, the share of public consumption expenditures is simulated to rise considerably over time. In the scenario "reference", it grows from 16.5 % in 2018 to 20.8 % in 2060. This is driven by the demography-related components health expenditures and public transfers (including pension claims), where per capita expenditures are markedly higher in the older age segments. On annual average, health expenditures increase by 2.4 %, public transfers by 2.2 % in the scenario "reference". In comparison, the third demography-related component education expenditures merely rises by 1.3 % on average. In per capita terms, annual average growth is expected to be 1.9 % for health expenditures and 1.7 % for public transfers. The total share of demography-related expenditures on total public expenditures is projected to increase to a level of about 75 % in 2060 under the scenario „reference". As the three main scenarios merely slightly differ in terms of their age structure, this development is almost identical in scenarios "high" and "low". It is most striking in the early years, when the most significant shifts in age structure occur.

In our model, the constraint on the public budget implies that the demographic pressure on the expenditure side also has repercussions on the the revenue side. Hence, private households are burdened with higher taxes and levies, which based on our definition of the public sector also includes payments to the compulsory health insurance (OKP). Given the high importance of this revenue category for public households and our assumption that net government borrowing grows with GDP, revenues from taxes and levies grow with similar rates as public expenditures. In the scenario "reference", the absolute burden grows by 2.0 % on annual average until 2060. In the scenario "high", annual growth amounts to 2.2 %, in the scenario "low" to 1.7 %. In per capita terms, this corresponds to annual increases of 1.5 %, respectively. Consequently, the share of tax and levy payments on GDP grows significantly in all three main scenarios. In the scenario "reference", it reaches a level of 45.9 % in 2060, compared to 33.1 % in 2018. This increase is also taking place in a continuous fashion, but with decreasing speed.

5.2 | Income distribution by age group

Our multi-generation model also allows for income comparisons among age groups. Demographic change can influence the income distribution by age in more than one way. First, it impacts gross income generated on the market: changes in the age structure affect economy-wide labor supply as well as capital accumulation, thereby domestic factor income. This applies to different age groups to a different degree. Another channel is public redistribution. Transfer flows between generations adjust, potentially both by changed tax burdens and transfer claims, influencing both net contributors and net recipients.

In principle, our model is able to capture both channels. However, it has to be borne in mind that transfer payments to members of different age groups had to be proxied based on household data, which implies a certain degree of imprecision. Moreover, by construction, a full adjustment of the public revenue side is assumed, as transfer claims per capita within the different age groups are assumed to grow with the (exogenous) total factor productivity. Results should therefore be interpreted as scenarios in which budget problems are exclusively handled by an increase in taxes and levies.

Table 2

	Age group						
Scenario	15-24	25-34	35-44	45-54	55-64	65-74	75+
% change in disposable income 2018-2030							
Benchmark	25.3%	12.1%	10.8%	11.7%	12.0%	9.8%	9.2%
Reference	12.4%	4.9%	3.9%	4.5%	3.8%	6.3%	6.7%
High	13.2%	5.5%	4.5%	5.2%	4.6%	7.0%	7.1%
Low	11.4%	4.1%	3.2%	3.8%	2.9%	5.6%	6.2%
% change in disposable income 2018-2045							
Benchmark	54.9%	32.9%	29.6%	30.0%	30.4%	27.2%	23.0%
Reference	26.9%	13.1%	10.6%	10.4%	10.2%	14.0%	17.5%
High	26.8%	14.3%	11.9%	11.7%	11.8%	15.4%	18.5%
Low	27.0%	11.9%	9.3%	9.0%	8.6%	12.4%	16.5%
% change in disposable income 2018-2060							
Benchmark	79.5%	56.3%	52.7%	52.8%	52.8%	48.3%	39.4%
Reference	36.4%	23.8%	20.9%	20.0%	18.6%	24.8%	30.0%
High	36.2%	24.6%	21.9%	21.1%	20.0%	26.4%	31.1%
Low	36.8%	23.2%	20.1%	19.0%	17.4%	23.3%	28.8%

Source: own calculations

Against this background, our simulation results show sizable effects of demographic change on the future evolution of disposable income by age group (see Table 2). Comparing the three main scenarios on the one hand and the scenario without changes in age structure are most insightful. In the latter scenario, all age segments would experience sizable increases in average per capita net incomes. As tax rate and OKP levy remain unchanged in this scenario, this is driven by the impact of TFP-growth on labor productivity and the resulting market renumeration. The picture looks different for the main scenarios. While again all age groups can benefit from TFP-growth, the income increases for age groups in the young and (in relative terms) especially the middle age segment are considerably smaller than in the scenario without changes in age structure. The main reason is that different age segments are affected differently by the expenditure-induced increase of the tax burden. Those age segments exhibiting the highest rates of labor force participation bear the lion's share of the tax increase. Given our assumption that fiscal adjustments only occur on the revenue side, older age segments are impaired to a minor degree.

6 | Sensitivity analysis

The demographic scenarios developed by the Swiss Statistical Office (FSO) are based on a set of diverse and intertwined assumptions regarding the evolution of fertility rates, mortality rates, labor force participation and net immigration. The main scenarios analyzed above differ in all three aspects. To gain more insights into the effects of specific sociodemographic parameters, a sensitivity analysis is required. For this purpose, the FSO has also presented a set of alternative scenarios that differ from the scenario „reference" with respect to certain parameters. In the following, we present simulation results based on some of these alternative scenarios. Specifically, we investigate the implications of a scenario with high fertility rates (*Scenario A-01-2015* in FSO nomenclature), a scenario with high net immigration (*Scenario A-06-2015*), a scenario with improved compatibility of work and family life (*Scenario A-09-2015*), and a scenario with enhanced labor force participation of the elderly (*Scenario A-11-2015*). While the two former scenarios address the age distribution of the population, the two latter affect the age-specific labor force participation rates. Features of these scenarios are discussed in Section 4. Sensitivity with regard to net immigration and family friendliness is especially relevant when evaluating the effectiveness of policies towards demographical change.

Table 3

Annual GDP growth in % (5-year averages)

Scenario	2018-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2051-2055	2056-2060
Absolute								
Reference	1.57%	1.36%	1.34%	1.17%	1.09%	1.02%	0.96%	0.97%
Alternative scenarios								
High fertility	1.57%	1.37%	1.36%	1.23%	1.17%	1.11%	1.05%	1.07%
High net immigration	1.87%	1.65%	1.61%	1.35%	1.23%	1.15%	1.07%	1.06%
Improv, compat. of work and family life	1.79%	1.47%	1.41%	1.23%	1.12%	1.04%	0.95%	0.97%
Enh. labor force particip. of the elderly	1.88%	1.56%	1.44%	1.23%	1.15%	1.07%	0.98%	0.97%
Per capita								
Reference	0.63%	0.52%	0.64%	0.75%	0.81%	0.81%	0.80%	0.86%
Alternative scenarios								
High fertility	0.58%	0.47%	0.60%	0.75%	0.84%	0.83%	0.81%	0.87%
High net immigration	0.64%	0.56%	0.64%	0.70%	0.80%	0.79%	0.76%	0.81%
Improv, compat. of work and family life	0.85%	0.63%	0.70%	0.81%	0.85%	0.82%	0.79%	0.85%
Enh. labor force particip. of the elderly	0.94%	0.71%	0.73%	0.80%	0.86%	0.85%	0.81%	0.85%

Source: own calculations

Table 3 presents simulation results for GDP growth for all of these cases, mirrored against the results for the scenario „reference". While all alternative scenarios entail boosts for GDP growth compared to the reference case, their magnitudes and timing differ considerably among the scenarios. In the scenario with increased net immigration, the boost is limited to the early years of the forecasting period. In these years, the additional inflow of immigrants stemming to a large part from the young and middle-aged population segment implies a more favorable development of total labor force participation as well as of age-dependent labor productivity. As a consequence, both absolute and per capita growth are fostered. However, this effect is limited to the period until the mid-2030s. The main reason is that an equivalent ageing process is expected for the migrant segment of the population. In principle, this also holds for the impact of adjustments in age-specific labor market participation rates, as they are considered in the alternative scenarios „improved compatibility of work and family life" and „enhanced labor force participation of the elderly". In these scenarios, the increase in manpower boosts growth, both in comparison to the basic scenarios and the scenario with higher immigration. But here as well the effect tapers off gradually in later periods. This is due to the fact that in these scenarios adjustment processes in participation rates are assumed to be more or less completed during the 2030s. In the „higher fertility" scenario, by contrast, the positive effect does not materialize before the last part of the forecasting period. In fact, the short-run impact in per capita terms is even negative. Given that it takes some time until the new generation can enter the labor market, this is quite as expected.

In a long-run comparison, the „higher fertility" scenario yields the lowest GDP levels for 2060 of all alternative scenarios, both in absolute and per capita terms. In this regard, the scenario with increased net immigration merely performs best in absolute terms, but second-worst in per capita terms. Hence, the scenario with increased participation rates are diagnosed to be associated with the most positive long-term impacts in per capita GDP, with the scenario featuring higher participation of the elderly performing best. However, comparing results with those of the main analysis (Table 1), it is still apparent that neither of the alternative scenarios can compensate fully for the impact of ageing. The synthetic scenario without changes in age structure yields consistently higher GDP growth than each alternative scenario throughout the whole simulation period.

7 | Conclusion

In general, our projections over the time horizon 2018-2060 document a significant loss in economic growth caused by the projected changes in the age structure of the Swiss population, both in absolute and per capita terms. Likewise, the process of ageing would have consequences for the composition of the Swiss Gross Domestic Product by expenditure category. The share of government spending on domestic value added is simulated to in-crease, primarily due to its demography-related components. If no changes in age-specific per-capita spending are going to take place, a higher net burden with taxes and other public charges would be the consequence, which would according to our simulations primarily hit the middle-aged population. As a result, less than average income increases are expected for this age segment.

The alternative scenarios reveal that increased immigration, in the magnitude postulated by the corresponding scenario, can compensate for the implications of ageing on GDP per capita merely to a minor degree. In principle, this also holds for the impact of adjustments in age-specific participation rates, as they are considered in the remaining alternative scenarios. In these scenarios, increased labor market participation leads to a more favorable development of per capita GDP, both in comparison to the basic scenarios and the scenario with higher immigration. However, increased propensity to work can likewise not fully compensate for the negative impacts of ageing.

With regard to potential policy implications, the level of abstraction involved in our macro-economic modelling calls for some restraint. On a more fundamental level, our results give rise to the expectation that the political debate on intergenerational equity will intensify.

8 | Literature

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Table A 1: Data sources

Indicator	Source	German Term
Production Side / goods market		
Gross Domestic Product	Swiss National Accounts	Volkswirtschaftliche Gesamtrechnung (VGR)
Gross Value Added in Factor Prices	Swiss National Accounts	VGR
Net Operating Surplus	Swiss National Accounts	VGR
Total Compensation of Employees	Swiss National Accounts	VGR
Relative Compensation by Education level	Swiss Education Statistics	Schweizer Bildungsstatistik
Trade		
Export Volume of Goods and Services	Swiss Foreign Trade Statistics	Statistik des Außenhandels der Schweiz
Import Volume of Goods and Services	Swiss Foreign Trade Statistics	Statistik des Außenhandels der Schweiz
Capital Exports	Swiss National Bank	Schweizer Nationalbank
Capital Imports	Swiss National Bank	Schweizer Nationalbank
Private Households		
Demographic Development in Switzerland 2015-2060- population by age groups	Federal Statistical Office (FSO)- Projections regarding demographic development (reference scenario, high scenario, low scenario)	Bundesamt für Statistik- Szenarien zur Bevölkerungsentwicklung der Schweiz (Referenzsszenario, hohes Szenario, tiefes Szenario)
Demographic Development in Switzerland 2015-2060- deaths by age groups	Federal Statistical Office (FSO)- Projections regarding demographic development (reference scenario, high scenario, low scenario)	Bundesamt für Statistik- Szenarien zur Bevölkerungsentwicklung der Schweiz (Referenzsszenario, hohes Szenario, tiefes Szenario)
Private Consumption	Swiss National Accounts	VGR
Household Income and Expenditure by age groups	Swiss Population and Households Statistics	Schweizer Statistik der Bevölkerung und der Haushalte
Public Finance		
Total Public Expenditure	Swiss National Accounts	VGR
Public Expenditure in Education	Federal Statistical Office (FSO)- General government expenditure by function	Bundesamt für Statistik- Staatsausgaben nach Ausgabenbereichen
Public Education in Health	Federal Statistical Office (FSO)- General government expenditure by function	Bundesamt für Statistik- Staatsausgaben nach Ausgabenbereichen
Public Transfers	Federal Statistical Office (FSO)- General government expenditure by function	Bundesamt für Statistik- Staatsausgaben nach Ausgabenbereichen
Fiscal Public Revenue	Eidgenössische Finanzverwaltung	Federal Finance Administration
Non-Fiscal Public Revenue	Eidgenössische Finanzverwaltung	Federal Finance Administration
Labor Market		
Total Working Population by Education Level and Age Group	Federal Statistical Office (FSO)- Work and Income	Bundesamt für Statistik- Arbeit und Erwerbs
Labor Volume by Age Group	Federal Statistical Office (FSO)- Work Volume Statistic	Bundesamt für Statistik- Arbeitsvolumenstatistik
Capital Markets		
Gross fixed asset investment	Swiss National Accounts	VGR
Private Savings	Swiss National Accounts	VGR

Table A 2: Growth rates for different expenditure categories

Annual real growth in % (5-year averages)

Scenario	2018-2025	2026-2030	2031-2035	2036-2040	2041-2045	2046-2050	2051-2055	2056-2060
				Gross fixed capital formation (absolute)				
Benchmark	1.94%	1.86%	1.40%	1.12%	1.25%	1.16%	1.10%	1.09%
Main scenarios								
Reference	1.05%	1.31%	1.08%	0.87%	1.01%	0.84%	0.92%	1.09%
High	1.37%	1.62%	1.27%	1.04%	1.23%	1.04%	1.10%	1.26%
Low	0.69%	0.97%	0.85%	0.73%	0.78%	0.60%	0.71%	0.90%
				Private consumption (absolute)				
Benchmark	2.08%	1.99%	1.87%	1.59%	1.42%	1.34%	1.25%	1.19%
Main scenarios								
Reference	1.41%	1.26%	1.19%	1.02%	0.93%	0.87%	0.83%	0.85%
High	1.69%	1.54%	1.47%	1.25%	1.15%	1.09%	1.04%	1.04%
Low	1.12%	0.95%	0.89%	0.77%	0.70%	0.65%	0.61%	0.63%
				Public expenditures (absolute)				
Benchmark	2.08%	1.99%	1.87%	1.59%	1.42%	1.34%	1.25%	1.19%
Main scenarios								
Reference	2.35%	2.35%	2.21%	1.88%	1.69%	1.60%	1.49%	1.36%
High	2.59%	2.60%	2.46%	2.11%	1.92%	1.83%	1.74%	1.62%
Low	2.11%	2.10%	1.94%	1.63%	1.44%	1.34%	1.22%	1.08%
				Public expenditures (per capita)				
Benchmark	1.14%	1.14%	1.16%	1.16%	1.15%	1.12%	1.09%	1.07%
Main scenarios								
Reference	1.41%	1.50%	1.50%	1.45%	1.42%	1.38%	1.33%	1.25%
High	1.34%	1.44%	1.46%	1.45%	1.43%	1.39%	1.34%	1.27%
Low	1.46%	1.56%	1.54%	1.46%	1.40%	1.36%	1.31%	1.22%
				Demography-related public expenditures (per capita)				
Benchmark	1.12%	1.12%	1.13%	1.13%	1.12%	1.10%	1.08%	1.07%
Main scenarios								
Reference	1.34%	1.55%	1.61%	1.61%	1.56%	1.53%	1.48%	1.36%
High	1.32%	1.57%	1.63%	1.65%	1.59%	1.53%	1.49%	1.38%
Low	1.36%	1.56%	1.60%	1.57%	1.52%	1.50%	1.46%	1.33%

Source: own calculations

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