Projektbericht

Research Report

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Aging, Immigration and the Welfare State in Austria

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Abstract

Demographic changes are increasingly putting pressure on the financing of European welfare states. The increase in life expectancy and decrease in fertility lead to an overall population aging. Unchanged retirement behavior would lead to an increasing deficit in the financing of social insurances, including retirement pensions and medical care. As migrants are on average younger, more immigration could help reduce the age dependency ratio and improve the financing of social insurances. Several studies have quantified the effect of migration on the financing of the welfare state and evaluated pension reforms, but none considers endogenous retirement decisions. Yet, households adjust their behavior after policy reforms. This study is the first general equilibrium analysis of the effect of migration and aging on social security financing and of pension reforms with endogenous retirement decisions. It finds a small to moderate positive effect of migration in Austria and that medical care has an increasing role in the deficit of social security financing. The study finds that taking constant retirement age overestimates the benefit of migration. It also evaluates labor market impacts, including endogenous human capital accumulation.

Keywords: Aging, international migration, social security and public pensions, wage level and structure, unemployment, human capital, general equilibrium models
JEL-Classification: D58, F22, H55, J11, J24, J31, J64

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1 Introduction

The increase in life expectancy and low fertility has large demographic consequences. Population aging poses strong policy challenges, as retirement and health care needs to be financed by an increasingly smaller share of the population. Jaag, Keuschnigg and Keuschnigg (2010) estimate that the deficit of pension financing in Austria would move from 2.5% of GDP in 2010 to 10% of GDP in 2050 if no reform is undertaken. Migrants are on average younger and could thus have a net positive impact on pension financing. Several authors have quantified the impact of immigration on the financing of social security insurances but none have considered retirement behavior reactions to policy change, nor taken the increase in health care costs into account. This study is the first general equilibrium analysis which quantifies the impact of immigration, population aging and health care on the financing of social security insurances with endogenous retirement decisions. The analysis is performed for Austria, one of the country with the biggest pension funding challenge in Europe, and compares the effectiveness of several pension policy reforms taking into account population aging and migration.

On top of the scientific contribution, our study can also feed in the policy debate in particular for Austria. Together with Belgium and Germany, the European Commission for instance considers that Austria has relatively sound public finance management overall but states that "*reforms to address rising age-related costs will be indispensable*" (p.5, European Commission (2009)). Pension reforms carry a heavy political cost and are notoriously difficult. However, the public finance difficulties following the 2007 crisis have accelerated the implementation of pension reforms in most OECD countries, including Austria (OECD (2012)).

The increase in longevity and decrease in fertility have been the two main domestic demographic changes since the end of the second World War. Data and projections from Statistik Austria illustrate recent variations. Life expectancy was 73 years at birth in 1960 for women, 83 years in 2010 and projected to reach 90 years in 2050. On the other hand, the ratio of newborns to the population between 15 and 50 has decreased from 0.037 in 1960 to 0.022 in 1990 and 0.018 in 2010. Statistik Austria predicts this figure to stabilize at a comparable low level in the future, namely 0.021 by 2040.

These demographic changes lead to a population structure with a larger share of old households. According to projections from OECD (2011b), the ratio of the population aged 20-64 over that aged 65 and more should decline from 3.5 in 2010 to 1.8 in 2050 in Austria and the EU27. If the effective retirement age remains unchanged, this means that the number of retired persons that each worker needs to support would essentially double over the next 40 years, a significant shift in the distribution of resources across generations in the economy.

The aging of the population poses challenges in other domains than retirement financing. For example, aging is associated with an increase in health care expenditures. Taking into account aging and other changes, the share of health care expenditure represented 4% of total output in Austria in 1960 and increased to 11% in 2009 (OECD (2011a)). One of the detailed patterns on health care is that expenses are increasing in age. Population aging thus leads to the challenge of financing age-increasing health care insurance, on top of retirement pensions (Feldstein (2006)).

While longevity and fertility variations have been the main domestic demographic novelty, migration has been the main change at the international level. Net immigration flows into Austria have increased almost by a factor 10 between the early 1960's and the late 2000's. In 2010, 17% of the working age population in Austria was foreign born, one of the largest fraction among OECD countries (Krause and Liebig (2011)).

Labor market integration of foreign born workers only recently received significant policy attention in Austria, in part because outcomes have been good over the past decades (Krause and Liebig (2011)). Immigration poses a number of policy challenges in the economic dimension and other dimensions, but also carries opportunities. In particular, on average migrants tend to move to other countries early in their adult life. The average age of foreign households is lower than that of native households. Migration could thus compensate population aging and increase the ratio of working age to retired households.

This idea is not new (e.g. Borjas (1994), Storesletten (2000)) and there have been several economic studies of the effect of migration on public finances and retirement pensions in particular. The empirical literature has focused on the effect of migration on labor markets, with few analysis of the public finance impact (e.g. Kerr and Kerr (2011)). The theoretical literature comprises generational accounting and general equilibrium simulation analysis. This literature generally finds positive effects of migration on public finances, but these effects are small and insufficient to deal with the population aging challenge.

Our main contribution to the literature is that we model retirement behavior responses to changes in policy when population ages and there is migration, which we believe is important when retirement pension reforms are considered. Many existing theoretical models allow for endogenous labor supply decisions, but only along the intensive margin (hours). There exist general equilibrium analyses with endogenous labor supply decision along intensive and extensive margins (retirement, participation and unemployment), taking into account the effect of population aging, but none which also take into account the impact of migration. A second contribution of our analysis is to take into account age-dependent health care financing. The study we undertake is thus the first general equilibrium analysis of the effect of migration on social security financing with an aging population and endogenous labor supply along intensive (hours) and extensive (participation, retirement and unemployment) margins. Several studies found that the skill level of immigrants impacts differently economic outcomes so we use a model with several education levels, allowing for endogenous decisions in human capital accumulation. We also use a detailed model of the labor market because the inflow of immigrants can have adverse effects on unemployment insurance outlay, which has to be taken into account when assessing the full effect of immigration on public finances.

The literature contains general equilibrium analyses of migration and aging effects with endogenous labor supply along the intensive margin (Razin and Sadka, 2000; Storesletten, 2000; Kemnitz, 2003; Fehr, Jokisch and Kotlikoff, 2003, 2004; Schou, 2006; Izquierdo, Jimeno and Rojas, 2010; Lacomba and Lagos, 2010; Jinno, 2011). There are also analyses of the aging effects with endogenous labor supply along both dimensions (Jaag, Keuschnigg and Keuschnigg, 2010) or a single dimension (Börsch-Supan and Ludwig, 2010), but without looking at the effect of migration. The literature also contains analyses of the migration effect in partial equilibrium settings (Lee and Miller, 2000, for the US; generational accounting studies such as Bonin, Raffelhüschen and Walliser, 2000, for Germany, Collado, Iturbe-Ormaetxe and Valera, 2004, for Spain and Mayr, 2005, for Austria) and exogenous labor supply settings (Casarico and Devillanova, 2003; Leers, Meijdam and Verbon, 2004; Geide-Stevenson and Ho, 2004; Borgy, Chojnicki, Le Garrec and Schwellnus, 2009), allowing for analysis with multi-country models, endogenous migration, political economy or other refinements.

Our approach is to extend existing overlapping generations models with demographic changes and exogenous migration flows. For a better modeling of demographic variations, we use an overlapping generation structure with age-dependent mortality rates (Grafenhofer et al. (2007)), which has been enriched with unemployment and endogenous labor supply decisions along several margins (Jaag et al. (2010)), different skill levels (Berger et al. (2009)) and exogenous migration flows (Berger et al. (2011)). We add a more precise modeling of demographic changes using exogenous fertility rates variations, as well as more precise skill acquisitions by migrants.

We use demographic data and several projections from Statistik Austria on mortality rates, fertility rates and migration flows between 2010 and 2075 to simulate the impact of population aging and migration on economic outcomes, including output growth, labor supply and public finances. Several demographic change scenarios from Statistik Austria are compared, with or without pension reforms[1]. These reforms include variations in retirement age, pension benefits and social security benefits. The model capture households behavior adjustment in saving and along several dimensions of labor supply, including retirement decisions.

Simulations deliver three main findings. First, the effect of aging on the social security finances is different if health insurance is taken into account or not. In the main demographic scenario, the overall social security deficit rises from 6.8% in 2010 to 14.7% of GDP in 2050, while the retirement pension deficit alone rises from 4.5% to 9.7% of GDP, the difference coming from health expenditures. Second, taking into account endogenous retirement decisions, migration helps to reduce the social security deficit in a small to moderate fashion, without resorbing it. An average increase of about 25% of projected migration in Austria would improve the dependency ratio in 2050 from 50.6% to 48.6%, but migrants also age. As a result, the total social security deficit would only be reduced to 13.9% of GDP in 2050. To attain a similar social security deficit without additional migration, the effective retirement age would have to be raised by 1 year, average social security contributions increased by 6.7% or average pension benefits reduced by 11.2% (compared to the mechanical decrease of 7.9%). To isolate the effect of migration and aging, government budget is balanced with lump-sum taxes, an unrealistic policy instrument. Adding distortionary taxes would worsen the deficit. Third, it is important to model endogenous retirement decisions, as taking constant retirement age bias results on immigration and pension reforms. Under constant decisions, the average pension benefits would have to be cut by 12.2% to reach the same deficit reduction as higher immigration, overestimating its benefits.

Policy reforms analyses also show that moderate single instrument reforms would not be able to contain social security deficit. Moderate to strong increases in the effective retirement age, reductions in pension benefits and increases in social security contributions would be needed to keep the social security deficit constant. From the single instrument reforms, increases in retirement age are the least damaging to economic growth. A simple 2/3 retirement age increase rule-of-thumb is sufficient for pension financing but not for total social security financing related to aging, for which a more appropriate rule-of-thumb is 8/7, the difference coming from age-increasing health costs. Natives adjust their education decisions to compensate for the relative imbalance in the immigrant skill distribution. Simulations also illustrate the importance of overall economic growth.

The next section reviews the existing literature and the following one presents the main demographic stylized facts about Austria. Section 4 presents the novelties about the model in a simplified framework. Section 5 presents and discusses the simulation results of the full scale numerical model. Section 6 concludes.

[1] We take the pension policy situation as-is and do not take into account planned future pension reforms.

2 Literature review

As noted in the introduction, the study we perform is the first general equilibrium analysis of the effect of migration on social security financing with an aging population and endogenous labor supply along intensive (hours) and extensive (participation, retirement and unemployment) margins. In this section, we present previous studies from the literature and highlight the differences to our analysis.

Surveys by Borjas (1999), Hanson (2008) and Kerr and Kerr (2011) conclude that the empirical literature on the effect of migration on public finances is still limited. Tentative findings are that migration has small effects.

There is a large empirical and theoretical literature on the effect of migration on labor markets, surveyed for instance by Borjas (1999). Textbook theory would suggest that immigration depresses the wage of natives because of increased labor supply. As noted by Borjas et al. (2008) for instance, the literature has however not yet reached a consensus on this effect. As they discuss, the key empirical finding of Borjas (2003) that immigration depresses native wages and opposite results by Ottaviano and Peri (2012) critically depend on the assumption made on the substitutability of native and foreign workers labor supply, which empirically is still an open question.

Given the focus of the study on migration and public finance, we do not review the literature on migration and labor markets and refer to Borjas (1999). As noted, the empirical literature on migration and public finance is limited. We therefore only present and discuss the theoretical literature on migration, aging and public finance, starting with generational accounting studies and continuing with general equilibrium analysis.

Mayr (2005) performs a generational accounting analysis for Austria and finds that immigration has a positive impact on the social security financing taking into account population aging, but is not sufficient to achieve intertemporal balance. For instance, higher migration flows of about 40% would reduce the intertemporal public debt liability by less than 3%. High skill migration would be more successful, reaching a reduction of 10% of the liability, but remains insufficient[2].

Bonin et al. (2000) reach similar conclusions for Germany, while Collado et al. (2004) obtain similar results for Spain. For instance, they find that the overall tax burden would need to be increased by 8.8% to reach intertemporal balance if there was no immigration to Spain, compared to 7.9% with current estimated migration flows.

Generational accounting provides interesting benchmark information. In particular, it allows to have a sense of the burden which fall on current and future generations. As noted for instance by Buiter (1997) however, generational accounting does not capture general equilibrium effects. Feedback effects of factor prices on labor supply provision, including retirement age, are key behavioral dimensions of the pension system financing. General equilibrium analysis are thus preferable for evaluating the effect of policy reforms or demographic changes on economic outcomes.

As noted in the introduction, there is no general equilibrium analysis of the effect of migration on social security financing with an aging population and endogenous labor supply along intensive (hours) and extensive (participation, retirement and unemployment) margins.

There exist theoretical analysis of the migration and aging effects with endogenous labor supply along the intensive margin (Razin and Sadka, 2000; Storesletten, 2000; Kemnitz, 2003; Fehr,

[2]Deeg et al. (2009) perform a generational accounting for Austria which takes into account the 2005 reforms (unlike Mayr (2005)) but does not allow to identify the effect of migration.

Jokisch and Kotlikoff, 2003, 2004; Schou, 2006; Izquierdo, Jimeno and Rojas, 2010; Lacomba and Lagos, 2010; Jinno, 2011) and there is analysis of the aging effects with endogenous labor supply along both dimensions (Jaag, Keuschnigg and Keuschnigg, 2010) or a single dimension (Börsch-Supan and Ludwig, 2010), but without looking at the effect of migration. There are also analysis of the migration effect in partial equilibrium settings (Lee and Miller, 2000, for the US, on top of generational accounting studies) and exogenous labor supply settings (Casarico and Devillanova, 2003; Leers, Meijdam and Verbon, 2003 ; Geide-Stevenson and Ho, 2004; Borgy, Chojnicki, Le Garrec and Schwellnus, 2009), allowing for analysis with multi-country models, endogenous migration, political economy or other refinements.

Below we present briefly the various studies and their main findings, starting with the ancestors of the model that we use.

Grafenhofer et al. (2007) introduce an overlapping generation structure which allows for age-dependent mortality rates, a feature which is useful for the analysis of demographic changes. To illustrate the use of this so-called Probabilistic Aging model, authors quantify the effect of some demographic changes, namely higher life expectancy, but do not consider the effect of population aging as a whole nor migration.

Jaag et al. (2010) quantify the effect of population aging on retirement pension financing in Austria using the same overlapping generation structure and detailed labor markets, including unemployment and endogenous labor supply along several dimensions (hours; retirement; participation; unemployed search). They quantify the effect of pension reforms but do neither quantify the effect of migration nor incorporate age-dependent health expenditures.

Berger et al. (2011) also use the Probabilistic Aging basis, extend it in similar directions as Jaag et al. (2010), add endogenous human capital decisions, institutional details and exogenous migration flows. This model is used for a short run evaluation of the medium run impacts of a partial opening of the Austrian border to foreign immigrants, focusing on labor market outcomes. This model is the closest to the one we use for the study. The main differences are the focus of this paper on the long run analysis of fiscal sustainability and a more precise modeling of demographic changes, taking in particular projected fertility rates into account.

We now present existing theoretical analysis of the migration and aging effects with endogenous labor supply along the intensive margin.

Razin and Sadka (2000) build an overlapping generation model with a pay as you go (PAYG) pension system, endogenous education and intensive labor supply in the first period and retirement in the second period. They show analytically that low-skill immigration is a welfare improvement and public finances are improved if factor prices are constant, for instance if the country has good access to capital market so that migration has no influence on wages; results are ambiguous if factor prices are impacted by migration.

Storesletten (2000) uses an overlapping generations model to analyze the effect of increased immigration on public finances and the PAYG pension system, taking into account population aging and endogenous labor supply but with exogenous retirement. He finds that immigration has a positive effect, in particular of high skill immigrants. There is no quantification of the overall impact of immigration on the social security deficit.

Kemnitz (2003) analyzes the impact of low-skill immigration when labor markets are imperfect and there is unemployment in a two periods overlapping generation model, where retirement takes place in the second period. He finds a non-monotonous impact on per capita income: small volume immigration is first beneficial but then becomes a burden, as low-skill immigration increases the unemployment rate and thus the need for higher contributions.

Fehr, Jokisch and Kotlikoff (2003, 2004) analyze economic growth and pension financing in a three-regions model of the world, with overlapping generations, endogenous intensive labor supply, exogenous retirement dates, immigration flows and population aging. Assuming the same skill returns for natives and immigrants, they find that immigration does little to mitigate the pension financing deficit created by aging, whatever the skill focus of immigration policy.

Schou (2006) uses a dynamic CGE calibrated model for Denmark with a detailed overlapping generation structure but assumes exogenous participation rates, which can differ between natives and immigrants. He finds that increased immigration would affect public finance sustainability in a very small and negative way. Immigration of high-skill workers would have a positive impact, but still very small. On the other hand, a better economic integration of (existing and new) immigrants, so that they have the same participation rates, productivity, etc. as natives, would have a significant positive impact on public finances.

Izquierdo et al. (2010) use a CGE overlapping generation model with endogenous labor supply, exogenous retirement dates and differences in skill levels between natives and immigrants, calibrated for Spain. They find that more immigration would reduce the pension financing deficit but not sufficiently to eliminate the deficit. The skill composition of immigration has little effect.

In an overlapping generation model in continuous time with exogenous retirement dates, Lacomba and Lagos (2010) show analytically that voters favor low-skill immigration in spite of a redistributive PAYG system, since only young voters might suffer from immigration and reduced pensions, while older workers and retirees will benefit from increased contributions.

Jinno (2011) confirms analytically the result of Storesletten (2000) that only admitting sufficiently many high skill immigrants can help PAYG funding, in the context of costly assimilation of immigrants in the labor market (immigrants kids need more time in education to acquire the same skill level) in a two periods overlapping generation model, where retirement takes place in the second period.

Börsch-Supan and Ludwig (2010) contend that while the challenge of financing public pension system with an aging population is well-known, there are few analysis with behavioral reactions to reforms. Using an overlapping generation CGE model with endogenous labor supply along the intensive margin and exogenous labor supply along the extensive margin, an aging population and no migration, they show that combinations of pension and labor market reforms could easily offset the effect of aging on economic growth and pension financing if there was no labor supply behavioral reaction. Taking behavioral response into account and keeping pension finances balanced, there can be large GDP per capita losses, compared to secular growth.

We continue with existing theories of the economic effect of migration in partial equilibrium and exogenous labor supply settings, often allowing for analysis with multi-country models, endogenous migration, political economy or other improvements.

Lee and Miller (2000) use a partial equilibrium analysis and find that increased immigration would have a positive but small impact on the financing of social security in the US, in spite of the fact that immigrants have lower skills but thanks to their larger fertility, helping to keep the dependency ratio low.

Casarico and Devillanova (2003) investigate analytically endogenous education decisions, exogenous migration and PAYG pension financing in a two periods overlapping generation model with exogenous labor supply. In particular they show that a return migration scenario, where immigrants return to their country and receive lower benefit after retirement, does not increase welfare of natives.

Leers et al. (2004) model immigration endogenously and have a political economy context setting the tax to finance the PAYG pension system, with a production process without capital and with inelastic labor supply. They analytically show that the interplay of politics and economics can lead to emigration in the short run, before benefits of immigration are captured over the long run.

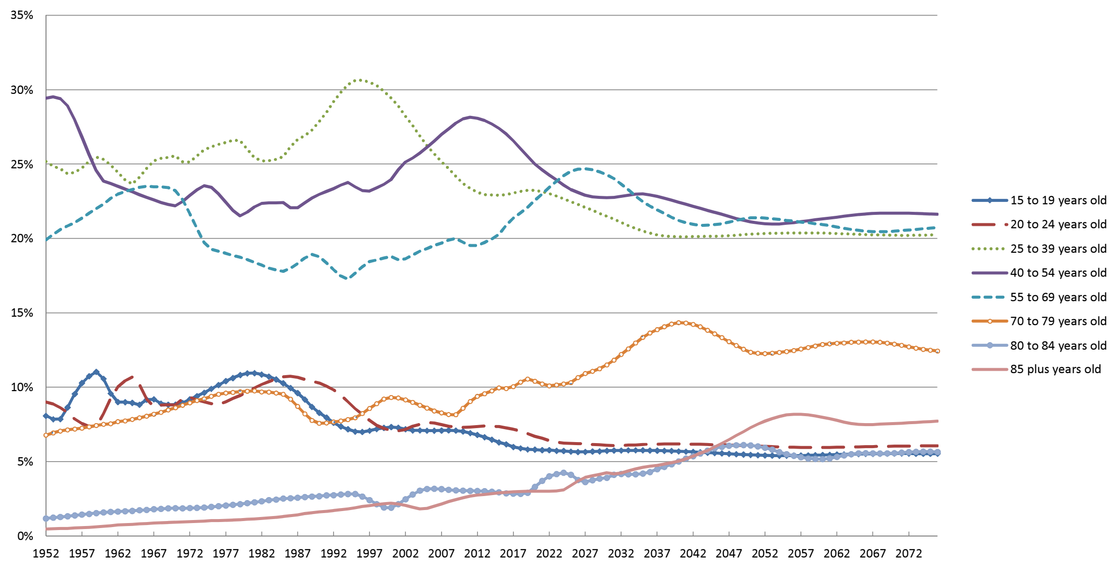
Geide-Stevenson and Ho (2004) analyze endogenous migration flows between two countries with overlapping generations which are identical, except for their social insurances and partial PAYG pensions. Labor supply is exogenous. They find a negative effect of migration along the transition path due to factor price effects.

Borgy et al. (2010) make a multi-country overlapping generations CGE analysis with endogenous migration flows, exogenous labor supply and population aging. Migration flows incentives are derived from an econometric estimation. They find that the financing of the PAYG pension system improves but the problem is not resolved and that output per capita is decreased by immigration, because the marginal product of labor is reduced.

3 Demographic change and migration in Austria

This section briefly illustrates the demographic challenges by presenting the key stylized facts emerging from the official population forecasts of Statistik Austria. Figure 1 shows the change in relative age group shares from 1952 to 2072, with a clear trend: young age groups lose and old age groups gain in relative size.

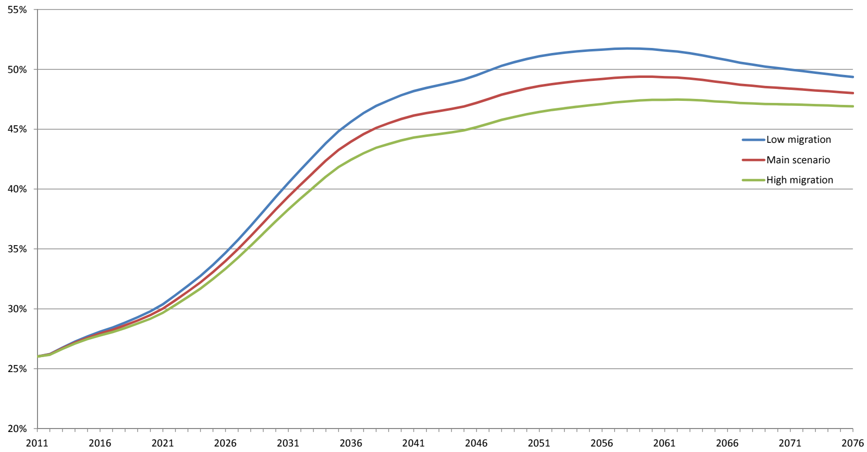
Figure 1: Forecast for population age structure, main scenario



Source: Data from Statistik Austria, main scenario.

The economic implications appear clearly in figure 2. The old age dependency ratio, i.e. the amount of 65+ individuals in proportion to the group of 15 to 65 year old, increases from around 27% to 50% within the next 50 years. This ratio has economic meaning because the first group has to be approximately financed by the second group, in the current pay as you go pension system. While it took about four working age persons in 2010 to finance one retired person in 2010, it will take two persons after 2050.

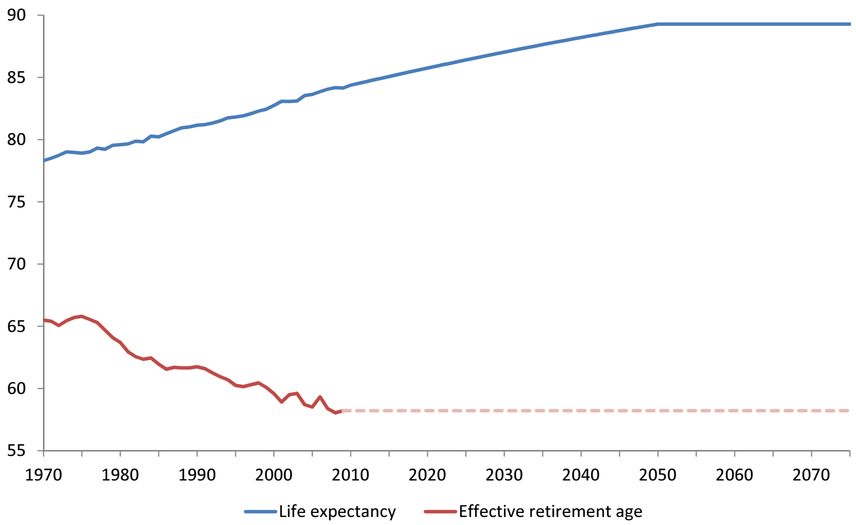
Figure 2: Old age dependency ratio for different scenarios



Source: Data from Statistik Austria.

The figure even underestimates the actual ratio of the paying-to-receiving population, for two reasons. First, the working age group contains non labor market participants and unemployed. For instance, the aggregated participation rate of the 15 to 55 year old was 77% in 2010. Second, there is a difference between the statutory retirement age (65 for men and 60 for women) and the effective retirement age, which is considerably lower. The evolution of the effective retirement age versus the life expectancy at age 65 is shown in figure 3 and illustrates the widening gap[3]. Hence, the ratio of the number of people who receive benefits to the number of people who actually contribute taxes and social security contributions is significantly higher than suggested by the old age dependency ratio.

Figure 3: Life expectancy at age 65 versus effective retirement age in Austria



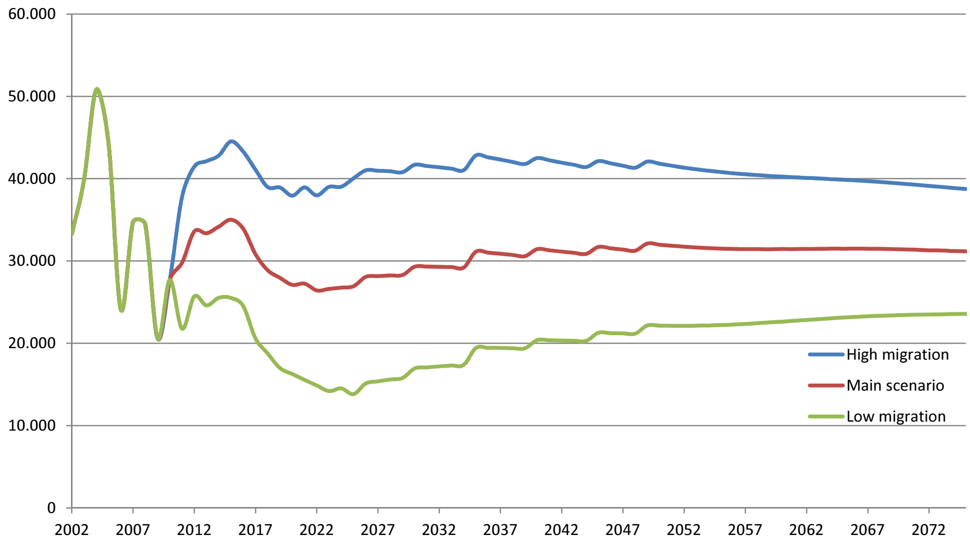
Notes: Time series are averaged over men and women.
Source: Data from Statistik Austria, Main Scenario and OECD.

The main goal of the paper is to quantify the effects of migration on the sustainability of the

[3]Because of unpredictability Statistik Austria simply leaves life expectancy from 2050 on unaltered while in principle it could continue to increase.

Austrian pension system. We again rely on predictions from Statistik Austria and formulate three different migration scenarios: main, low and high. Figure 4 illustrates the different prediction scenarios for net migration to Austria. The main scenario assumes a near constant flow of 30,000 net migrants to Austria per year, with a deviation in the low and high migration scenarios of about 30% in the medium run and about 25% in the long run.

Figure 4: Projected net migration flows to Austria



Source: Data from Statistik Austria.

Table 1 summarizes the age structure of net migration for Austrian and non-Austrian citizens and shows that net migration to Austria is concentrated at the young age groups. As illustrated in figure 2, the effect of migration on the dependency ratio is limited but not negligible: the difference between dependency ratios of the low- and high-migration scenarios can reach 5pp.

Table 1: Age structure of net migration to Austria in 2010

	Austrian citizens		Non-Austrian citizens		Total	
	absolute	in percent	absolute	in percent	absolute	in percent
0 to 14 years	-544	13.07%	4633	14.54%	4089	14.76%
15 to 19 years	-246	5.91%	4113	12.91%	3867	13.96%
20 to 24 years	-606	14.56%	8303	26.06%	7697	27.79%
25 to 39 years	-2096	50.35%	10605	33.29%	8509	30.72%
40 to 54 years	-881	21.16%	3750	11.77%	2869	10.36%
55 to 69 years	163	-3.92%	277	0.87%	440	1.59%
70 to 79 years	4	-0.10%	76	0.24%	80	0.29%
80 to 84 years	17	-0.41%	39	0.12%	56	0.20%
85+ years	26	-0.62%	62	0.19%	88	0.32%
sum	-4163	100.00%	31858	100.00%	27695	100.00%

Source: Data from Statistik Austria.

4 Model description

This section presents the key aspects of the employed simulation model and precisely describes how migration was added. The numerical simulations are based on a full scale model that incorporates additional decision margins and institutional details (like unemployment, endogenous training decisions and skills, disability insurance, etc.) which will only briefly be commented on in section 4.7.

4.1 Demography, probabilistic aging and migration

A key task of the model is to realistically capture the demographic structure and its changes in a given economy. In period t the economy is inhabited by N_t persons who differ along three characteristics: age (a), skill (i) and nationality (n). The overlapping generations structure relies on the concept of 'Probabilistic Aging' (see Grafenhofer et al. (2007)). There is a discrete amount of age groups A and individuals age stochastically which means that they switch from age group $a \in \{1, ..., A\}$ to age group $a+1$ with a given probability $1-\omega^a$ per period. If a period was a year then the expected time a person stays in age group a would be $1/(1-\omega^a)$ years. People start in age group $a = 1$ at a real age of 15 years. Once the last age group A is reached the aging probability drops to zero, i.e. $\omega^A = 1$. However, life does not end in age group A but can do so at any stage of life with death probability $1-\gamma^a$. As aging occurs stochastically two individuals in the same age group can differ by their life-cycle history $\alpha \in \mathcal{N}_t^a$, where $\mathcal{N}_t^a$ is the set of all possible biographies. A biography α is simply a vector that holds the information about the time an individual has aged from one age group to the other. Hence, the set of completely identical people that even share the same life-cycle history is $N_{\alpha,t}^{a,i,n}$. Aggregating over different biographies gives the number of persons in age group a with skill i and nationality n at time t

$$N_t^{a,i,n} = \sum_{\alpha \in \mathcal{N}_t^a} N_{\alpha,t}^{a,i,n}. \tag{1}$$

The skill distribution can be an endogenous outcome of individual decision making or exogenously given.[4] In any case the skill level is fixed before people enter age group $a = 1$, hence, there are no transitions between skill classes during a life-time. We restrict the analysis to three skill classes: low, medium and high, i.e. $i \in \{l, m, h\}$. Nationality can be *native* or *foreign*, i.e. $n \in \{I, A\}$. The main reason to make this distinction is that natives and foreigner will have different labor market outcomes, including different wages for the same eduation level. The laws of motion per age-skill-nationality cell are then given as

$$N_{t+1}^{1,i,n} = \gamma^1 \omega^1 N_t^{1,i,n} + New_{t+1}^{i,n} + Mig_{t+1}^{1,i,n}, \tag{2}$$

$$N_{t+1}^{a,i,n} = \gamma^a \omega^a N_t^{a,i,n} + \gamma^{a-1}(1-\omega^{a-1}) N_t^{a-1,i,n} + Mig_{t+1}^{a,i,n}. \tag{3}$$

$Mig_{t+1}^{a,i,n}$ is the net immigration flow to the given economy into a specific age-skill-nationality cell at the beginning of period $t+1$. For example, $Mig_{t+1}^{2,m,I}$ refers to the net inflow of natives, i.e. repatriates minus emigrants, that are part of age group 2 and of medium skill. The inflow into the first age group does not only consist of net migrants of the same age but also of new entrants $New_{t+1}^{i,n}$ to the labor market, i.e. persons born 14 years ago who turn 15 and hence enter the first

[4] In the full scale numerical model endogenous skill decision is incorporated, while in the simple illustration in the next section the skill distribution of newborns is taken as given.

age group. The number of new entrants is derived endogenously

$$New^{i,A}_{t+1} = \sum_j \varphi^{i,j}_A \left(\sum_{a=1}^{A} \zeta \cdot N^{a,j,A}_{t-14} \cdot f^{a,A}_{t-14} \right) + Mig^{0,i,A}_{t+1}, \tag{4}$$

$$New^{i,I}_{t+1} = \sum_j \varphi^{i,j}_I \left(\sum_{a=1}^{A} N^{a,j,I}_{t-14} \cdot f^{a,I}_{t-14} + (1-\zeta) \cdot N^{a,j,A}_{t-14} \cdot f^{a,A}_{t-14} \right) + Mig^{0,i,I}_{t+1}, \tag{5}$$

and consists of people born in the given economy and net migrants $Mig^{0,i,n}_{t+1}$ that turn 15 in $t+1$. The total number of newborns depends on the size of an age group and the age group specific fertility rate[5] $f^{a,n}_{t-14}$, 15 years earlier. The parameter ζ gives the assimilation rate, i.e. the probability with which the children of foreigners are indistinguishable from natives. This implies that it takes on average $1/\zeta$ generations until the offspring of foreign immigration has the same labor market prospects as a native. The parameters $\varphi^{i,j}_n$ capture skill transmission and denote the probabilities that parents of skill type j have children of skill type i. Aggregation over different characteristics can easily be done by summing up

$$N^{i,n}_{t+1} = \sum_{a=1}^{A} N^{a,i,n}_{t+1} \text{ and } N^{n}_{t+1} = \sum_i N^{i,n}_{t+1} \text{ and } N_{t+1} = \sum_n N^{n}_{t+1}. \tag{6}$$

4.2 Life cycle optimization

The life cycle consists of up to A age groups and is partitioned into three life stages characterized by the retirement decision age group a_r: the working stage for all $a < a_r$, the retirement-decision stage for $a = a_r$ and the retirement stage for all $a > a_r$. People in groups $a \leq a_r$ face the same decision problems concerning: participation, consumption and labor supply. Retired persons just decide how much to consume. The particularity of the retirement-decision stage is that non-participation is interpreted as retirement which implies different income flows $y^a_{\alpha,t}$ than non-participation during the working stage. Using an actuarially fair reverse-life insurance (see Blanchard (1985)) one can write the intertemporal budget constraint of an individual as follows

$$G\gamma^a A^a_{\alpha,t+1} = R_{t+1} Sav^a_{\alpha,t}, \qquad \text{with } Sav^a_{\alpha,t} \equiv \left[A^a_{\alpha,t} + y^a_{\alpha,t} - C^a_{\alpha,t}\right], \tag{7}$$

where G is the technological growth factor, A denotes assets, y are net income flows, R is the interest factor and C is consumption. All the individuals have preferences according to the following Epstein-Zin specification[6]

$$V^a_{\alpha,t} = \max \left[\left(Q^a_{\alpha,t}\right)^\rho + \gamma^a \beta \left(G\omega^a V^a_{\alpha,t+1} + G(1-\omega^a) V^{a+1}_{\alpha',t+1} \right)^\rho \right]^{1/\rho}. \tag{8}$$

Individuals in age groups $a \leq a_r$ maximize utility with respect to participation $\delta^a_{\alpha,t}$, hours worked $l^a_{\alpha,t}$ and consumption $C^a_{\alpha,t}$. The adjusted level of consumption is given as $Q^a_{\alpha,t} = C^a_{\alpha,t} - \varphi^a_l\left(l^a_{\alpha,t}\right) - \varphi^a_\delta\left(\delta^a_{\alpha,t}\right)$, where the effort costs functions $\varphi^a_l(\cdot)$ and $\varphi^a_\delta(\cdot)$ are convexly increasing. Retired workers just decide about optimal consumption, hence $Q^a_{\alpha,t} = C^a_{\alpha,t}$, $\forall a > a_r$. Migration is modeled as an exogenous event, hence, there is no active decision when or where to emigrate. We assume that economic conditions and the pension system in the target country are exactly the

[5] As the model does not distinguish between males and females the empirical fertility rate has to be corrected, e.g. by the share of females in a specific age group.

[6] The elasticity of intertemporal substitution is $1/(1-\rho)$ while individuals are risk-neutral. See Farmer (1990) and Weil (1990) for details.

same as in the domestic country from an individual point of view.[7] Emigration occurs randomly because of idiosyncratic personal reasons. This assumption implies that from an economic point of view individuals are indifferent between emigrating and staying, hence, the occurrence of emigration does not need to be explicitly modeled for the life cycle optimization. The resulting optimal consumption-savings decision is governed by a typical Euler-equation

$$\left(Q^a_{\alpha,t}\right)^{\rho-1} = \beta R_{t+1}\bar{\eta}^a_{\alpha,t+1}G^{\rho-1}, \tag{9}$$

where $\bar{\eta}^a_{t+1} \equiv \omega^a \frac{\partial V^a_{\alpha,t+1}}{\partial A^a_{\alpha,t+1}} + (1-\omega^a)\frac{\partial V^{a+1}_{\alpha,t+1}}{\partial A^{a+1}_{\alpha,t+1}}$ is the shadow price of a marginal increase in assets, taking aging into account.

4.3 Labor market and pension system

The per-period income flows are described as follows

$$y^a_{\alpha,t} = \begin{cases} \delta^a_{\alpha,t}\cdot(1-\tau^a_t)\cdot y^a_{\alpha,t,par} + \left(1-\delta^a_{\alpha,t}\right)\cdot y^a_{t,npar} & \text{if } a < a_r, \\ \delta^a_{\alpha,t}\cdot(1-\tau^a_t)\cdot y^a_{\alpha,t,par} + \left(1-\delta^a_{\alpha,t}\right)\cdot y^a_{\alpha,t,pens} & \text{if } a = a_r, \\ y^a_{\alpha,t,pens} & \text{if } a > a_r. \end{cases} \tag{10}$$

where $y^a_{t,npar}$ is the value of non-participating, such as home production. The value of participating $y^a_{\alpha,t,par} = l^a_{\alpha,t}\cdot\theta^a\cdot w_t$ depends on the chosen labor supply $l^a_{\alpha,t}$, an age dependent productivity parameter θ^a that can also differ depending on skill class and nationality and the wage rate w_t. The pension is given by $y^a_{\alpha,t,pens} = \sigma^{R,P}\nu^a P^a_{\alpha,t} + P^a_{0,t}$. It consists of a flat part $P^a_{0,t}$ and an income related part $\nu^a_t P^a_{\alpha,t}$, where $P^a_{\alpha,t}$ represents the acquired pension rights and ν^a_t is a scaling factor which can be used to cut or raise pension payments for given pension points. $\sigma^{R,P}$ reflects effects of the retirement decision on the pension payment in the so-called pension corridor. For $a > a_r$ the corridor does not play a role in which case $\sigma^{R,P} = 1$. The pension points evolve according to

$$GP^a_{\alpha,t+1} \quad = \quad R^{P,a}\left[M^a_\alpha + U^a\cdot P^a_{\alpha,t}\right], \tag{11}$$

where

$$\begin{array}{ll} M^a_\alpha = \delta^a_{\alpha,t}\cdot y^a_{\alpha,t,par},\ U^a = \sigma^P & \text{if } a < a_r, \\ M^a_\alpha = \delta^a_{\alpha,t}\cdot y^a_{\alpha,t,par},\ U^a = \sigma^{R,P} & \text{if } a = a_r, \\ M^a_\alpha = 0,\ U^a = 1 & \text{if } a > a_r. \end{array}$$

R^P denotes the notional interest rate with which pension claims increase, for example $R^P = G$ would imply full indexation to wage growth. The parameter σ^P captures the idea that pension claims obtained in early life can count less than more recent claims. The term $\sigma^{R,P} = \sigma^P + \sigma^P_1\left(\delta^a_{\alpha,t} - \delta^P\right)$ reflects the institutional characteristic of a pension corridor. If a worker retires prior to the statutory retirement age, captured by the decision δ^P, his current pension $y^a_{\alpha,t,pens}$ as well as his pension points for the future will be reduced by a factor σ^P_1. In anticipation of the result that labor supply does not depend on particular biographies, the first order condition for labor supply is

$$\frac{d\varphi^a_l\left(l^a_t\right)}{dl^a_t} = (1-\tau^a_t)\,w_t\theta^a + \frac{\gamma^a R^{P,a}\bar{\lambda}^a_{t+1}}{R_{t+1}\bar{\eta}^a_{t+1}}\cdot w_t\theta^a, \tag{12}$$

[7] This assumption is clearly only an approximation to reduce the model's complexity. As the model is later on calibrated for Austria, where people typically migrate to similar countries like Switzerland or Germany, this assumption is less harmful than if the model was simulated for a developing country.

where $\bar{\lambda}^a_{t+1} \equiv \omega^a \frac{\partial V^a_{\alpha,t+1}}{\partial P^a_{\alpha,t+1}} + (1-\omega^a) \frac{\partial V^{a+1}_{\alpha,t+1}}{\partial P^{a+1}_{\alpha,t+1}}$ is the shadow prices for a marginal increase of pension points. Equation (12) has an intuitive interpretation. The marginal costs of increasing labor supply have to be equal to the net wage rate per unit of labor (first term on the right hand side) plus the benefit for building up the pension stock (second term on the right hand side). The second term therefore reflects the built-in tax-benefit link. Let us turn to the optimal participation or retirement decision. As pension incomes will differ between different biographies α also optimal individual participation choices would differ which cannot be handled with the model. Instead it is assumed that individuals within an age-skill cell collectively choose the optimal participation rate which still allows analytical aggregation over biographies (see section 4.4). The first order condition for retirement can be written as

$$\frac{d\varphi^{a_r}_{\delta}\left(\delta^{a_r}_t\right)}{d\delta^{a_r}_t} = \left[\left(1-\tau^{a_r}_t\right) y^{a_r}_{t,par} - y^{a_r}_{t,pens}\right] + \frac{\gamma^{a_r} R^{P,a_r} \bar{\lambda}^{a_r}_{t+1}}{R_{t+1}\bar{\eta}^{a_r}_{t+1}} \cdot \left[y^{a_r}_{t,par} + \sigma^P_1 \bar{P}^{a_r}_t\right], \tag{13}$$

where $\bar{P}$ are average pensions points within an age-skill-nationality cell. Again the condition can be interpreted intuitively. The marginal costs of marginally increasing the retirement probability has to equal the net gain of doing so in that period (first term on the right hand side) plus the benefit of continuing to build up pension points which also includes improving future pensions by staying in the pension corridor (second term on the right hand side). The first order condition for participation for age groups $a < a_r$ has exactly the same structure and interpretation with the exception that net income is compared to $y^a_{t,npar}$ instead of $y^{a_r}_{t,pens}$ and that the very last term disappears as the pension corridor is only relevant in the retirement age group.

4.4 Aggregation

Decision making is computed for the smallest set of identical individuals, i.e. $N^{a,i,n}_{\alpha,t}$. As shown in Grafenhofer et al. (2007) the outcomes can be analytically aggregated such that the model can be analyzed without distinguishing between different biographies α. The aggregation of some variable X is done by summing over all biographies and weighting with the relative shares

$$X^{a,i,n}_t = \sum_{\alpha \in \mathcal{N}^a_t} X^{a,i,n}_{\alpha,t} \cdot N^{a,i,n}_{\alpha,t}. \tag{14}$$

For example, total private consumption per age-skill-nationality cell is given by $C^{a,i,n}_t = \sum_\alpha C^{a,i,n}_{\alpha,t} \cdot N^{a,i,n}_{\alpha,t}$. Effective labor supply L^S takes both labor supply margins and relative productivity into account, hence $L^{S,a,i,n}_t = \sum_\alpha \delta^{a,i,n}_{\alpha,t} \cdot l^{a,i,n}_{\alpha,t} \cdot \theta^a \cdot N^{a,i,n}_{\alpha,t}$. While aggregation of static relationships, like the first order conditions for labor supply and participation, is simple it becomes more involved for the difference equations for assets and pension points. Aggregation of (7) over all biographies α without migration and dropping the nationality index leads to

$$GA^{a,i}_{nomig,t+1} = R_{t+1}\left[\omega^a Sav^{a,i}_t + \left(1-\omega^{a-1}\right) Sav^{a-1,i}_t\right], \tag{15}$$

where in case of $a = 1$ the law of motion is reduced to $GA^{1,i}_{nomig,t+1} = R_{t+1}\omega^1 Sav^{1,i}_t$, i.e. the savings of new entrants is zero by assumption. For a proof see Grafenhofer et al. (2007). We assume that emigrants leave with the average assets of the corresponding age-skill-nationality cell. Hence, total assets per age group are

$$GA^{a,I}_{t+1} = \left(1 + \frac{Mig^{a,I}_{t+1}}{N^{a,I}_{t+1} + Mig^{a,I}_{t+1}}\right) GA^{a,I}_{nomig,t+1}. \tag{16}$$

Emigrants leave after having stayed in a specific age group already for some time. In contrast, when immigrants enter an age group they still have the expected full length in this age group ahead.[8] As average assets should be unaffected we assume that the immigrants arrive with the average assets of natives that just aged into the new age group a, hence

$$GA^{a,A}_{t+1} = R_{t+1}\left[\omega^a Sav^{a,A}_t + \left(1 - \omega^{a-1} + Mig^{a,A}_{t+1}/N^{a-1,A}_t\right) Sav^{a-1,A}_t\right]. \tag{17}$$

Next, we assume that pension points are not lost in case of emigration. The government deducts the pension points of emigrants from the current aggregate pension claim stock per age group and transfers the points to a separate account $\tilde{P}^{a,I}$ to keep track of its obligations to emigrated individuals. Once the emigrated worker abroad retires the domestic government transfers a pension for the points that where collected in the domestic country to the foreign country. We assume that emigrants age at the same speed and face the same survival probabilities compared to the natives that stayed. The transfer of pension points works symmetrically for the case of immigrants who arrive with the average pension points of individuals in the corresponding age-skill-nationality cell. When they retire they receive a pension based on the imported as well as domestically earned pension points from the domestic government. The domestic government is reimbursed by the foreign government for the expenses on pensions based on imported pension points. The aggregation of pension points works analogously to the aggregation of assets. Aggregating (11) over all biographies without migration gives

$$\begin{aligned} GP^{a,i}_{nomig,t+1} &= \omega^a \gamma^a R^{P,a}\left(N^{a,i}_t M^{a,i}_t + U^a P^{a,i}_t\right) \\ &+ \gamma^a\left(1-\omega^{a-1}\right) R^{P,a-1}\left(N^{a-1,i}_t M^{a-1,i}_t + U^{a-1} P^{a-1,i}_t\right) \\ &\equiv \omega^a \gamma^a \Gamma^{a,i} + \gamma^a\left(1-\omega^{a-1}\right)\Gamma^{a-1,i}. \end{aligned} \tag{18}$$

By the same arguments as above the total pension points per age group are given by

$$GP^{a,I}_{t+1} = \left(1 + \frac{Mig^{a,I}_{t+1}}{N^{a,I}_{t+1} + Mig^{a,I}_{t+1}}\right) GP^{a,I}_{nomig,t+1}, \tag{19}$$

$$GP^{a,A}_{t+1} = \omega^a \gamma^a \Gamma^{a,i} + \left[\gamma^{a-1}\left(1-\omega^{a-1}\right) + Mig^{a,A}_{t+1}/N^{a-1,A}_t\right]\Gamma^{a-1,i}. \tag{20}$$

After aggregating over biographies a variable $X^{a,i,n}_t$ is interpreted as an absolute number. Therefore, aggregation over age groups, skill classes or nationality is done by simply summing up, i.e. $X_t = \sum_{a,i,n} X^{a,i,n}_t$. For example, effective labor supply by skill class is given by $L^{S,i}_t = \sum_{a,n} L^{S,a,i,n}_t$.

4.5 Production

Production occurs in a competitive representative firm taking input prices, i.e. wage rates, the interest rate and the price of the output good, which serves as numeraire, as given. Using a small open economy assumption implies that the interest factor R is exogenous[9]. As changes in the

[8] Note that in principle *Mig* refers to *net* migration. For the timing of asset flows which is required for accounting we did not distinguish between emigration and immigration within the group of natives or foreigners. As observed net migration of natives is negative and net migration of foreigners is positive we approximated outflows by net migration of natives and inflows by net migration of foreigners.

[9] Miles (1999) investigates the effect of an aging population on savings in a general equilibrium OLG model with endogenous interest rates and labor supply, but exogenous retirement date. His simulations show that the saving rate may fall substantially as the working population becomes relatively smaller, but the impact on interest rates may be small precisely because the labor force also reduces.

production process are costly variations in the capital stock, these changes are subject to capital adjustment costs. This prevents unrealistic jumps in the capital stock as a response to different shocks given that the interest rate is taken as given. Wage rates are determined in three labor markets depending on the skill-level. The production function is linear homogenous and takes the following inputs

$$Y_t = F^Y \left(K_t, L_t^{D,l}, L_t^{D,m}, L_t^{D,h} \right). \tag{21}$$

The labor inputs from different skill classes are not perfect substitutes. Using a nested CES-specification we capture the idea that high skill labor and capital are more complementary than low skill labor and capital. On the other hand, we assume that native and foreign labor are perfect substitutes per efficiency unit if one conditions on the skill level. The literature has found that this assumption is not neutral: Borjas (2003) empirically finds that immigration depresses the wage of native workers while Ottaviano and Peri (2012) find little effects. The main reason that findings differ is that the first paper assumes perfect substitutability of native and foreign labor while the second assumes imperfect substitutability. As discussed by Borjas et al. (2008), direct empirical evidence on substitutability is still inconclusive. For simplicity thus, we follow Borjas (2003) and assume perfect substitutability.

This implies that after an increase in immigration gross wage rates will be bid down[10] in the short run. Once the capital stock adjusts accordingly this effect will be dampened. Whether average wages increase or fall in the long run then depends on compositional effects through changes in the relative sizes of the different skill classes. Formally, the firm maximizes its end of period value V^F which consists of the stream of discounted dividend payments χ:

$$\begin{aligned} V^F(K_t) &= \max_{I_t, L_t^{D,i}} \left[\chi_t + \frac{GV^F(K_{t+1})}{R_{t+1}} \right], \\ s.t. \quad & \chi_t = Y_t - I_t - J(I_t, K_t) - \sum_i w_t^i L_t^{D,i}, \\ & GK_{t+1} = \left(1 - \delta^K\right) K_t + I_t, \end{aligned} \tag{22}$$

where $J(\cdot)$ denotes the adjustment costs. Hence, in this simple illustration labor demands are pinned down by the marginal products and the wage rates, i.e. $Y_{L^{D,i}} = w^i$.

4.6 Government budget and market clearing

Equation (23) gives the primary balance, equal to public revenue minus public expenditure:

$$\begin{aligned} PB_t &= \sum_{a,i,n} \tau_t^a \delta_t^{a,i,n} y_{t,par}^{a,i,n} - \sum_{i,n} \left(1 - \delta_t^{a_r,i,n}\right) y_{t,pens}^{a_r,i,n} - \sum_{a \geq a_r, i, n} y_{t,pens}^{a,i,n} \\ &- \bar{g} \cdot N_t - \sum_{a,i,n} \bar{g}_{t,health}^a \cdot N_t^{a,i,n} + \tilde{P}_t^{a,I} + \tilde{P}_t^{a,A}. \end{aligned} \tag{23}$$

The revenues from labor income taxation are given in the first line. The second term in the first line gives the expenditure on retirees. The second line holds expenditure on exogenous public consumption which is proportional to the total population[11] and health expenditure which is age group specific. The last two terms reflects pension payments to emigrated natives $\tilde{P}_t^{a,I} < 0$ and

[10] In the full scale model also unemployment increases in addition.

[11] Imagine for example how a higher total population also induces higher costs for infrastructure, etc. On the other hand, public consumption can have a pure public goods character, e.g. expenses for defense that are only weakly related to the total size of population, see e.g. Lee and Miller (2000). As the first type of public consumption is more relevant in Austria, we chose the assumption of proportionality.

payments received from other governments for foreigners who immigrated $\tilde{P}_t^{a,A} > 0$. Government issues debt debt DG which evolves according to:

$$G\ DG_{t+1} = R_{t+1} \left(DG_t - PB_t \right) \tag{24}$$

The trade balance TB gives the difference of domestically produced and consumed units of the numeraire good. Note that we have to take the trans-border transfers of pension payments into account:

$$TB_t = Y_t - I_t - J_t - C_t - \tilde{P}_t^{a,I} - \tilde{P}_t^{a,A} - \bar{g} \cdot N_t - \sum_{a,i,n} \bar{g}^a_{t,health} \cdot N_t^{a,i,n}. \tag{25}$$

Foreign assets evolve according to the size of the trade balance. In addition, foreign assets have to be adjusted because emigrants and immigrants take their assets with them. Due to lack of data we had to neglect remittances that immigrants would transfer to their country of origin:

$$G\ DF_{t+1} = R_{t+1} \left(DF_t + TB_t \right) + \sum_a Mig_{t+1}^{a,I} \frac{GA_{t+1}^{a,I}}{N_{t+1}^{a,I}} + \sum_a Mig_{t+1}^{a,A} \frac{R_{t+1} Sav_{t+1}^{a-1,A}}{N_{t+1}^{a-1,A}}. \tag{26}$$

The clearing conditions for the labor markets and the asset market are standard and given in:

$$A_{t+1} = V_{t+1} + DF_{t+1} + DG_{t+1}, \qquad L_t^{D,i} = L_t^{S,i},\ \forall i. \tag{27}$$

The assets invested in the representative firm, assets invested abroad and government bonds have to sum up to the total asset holdings in the economy.

4.7 Full scale numerical model

The next section will present numerical simulation results using a full scale computational model that incorporates features which were not described in the simple presentation above. Those features are of no crucial importance for understanding the main qualitative mechanisms but are necessary for a quantitative exercise that should capture the main characteristics of the Austrian pension system and labor market. We will now briefly list the additional features. A detailed description of the full model without migration is provided by Berger et al. (2009). First, the full scale model adds one more labor market margin next to participation and hours worked, namely, unemployment. The probability of finding a job depends on the search effort of workers and the amount of vacancies created by the firm. Second, productivity θ^a is endogenous as firms and individuals can invest in training. Third, on top of the life long training there is an endogenous initial skill choice. Fourth, to match the observed asset distribution the model incorporates a warm-glow motive leading to inter-vivo transfers from the older to the younger age groups within a skill class but separate for natives and foreigners. Fifth, as the pathway to retirement via the disability pension system is important in Austria, this option is captured by the full scale model. However, the probability of entitlement to a disability pension is modeled as an exogenous shock, which implies that the pension reforms we consider exclude adjustments or changes of the disability pension system. Sixth, the full model additionally captures many institutional details concerning taxation and subsidization of individuals and firms. Most importantly, we distinguish between a social security budget paying for pensions, unemployment benefits, disability benefits and health insurance, financed by social security contributions of employers and employees on one hand and a general budget on the other hand. The general budget is financed by income, consumption and corporate taxes and is used to cover government expenditure, various subsidies and interest payment for government debt.

5 Scenario simulations

The goal is to quantify the effect of demographic changes and policy on public finances and economic outcomes over the next decades in Austria. We separate *demographic scenarios* from *policy reforms*. Section 3 presented the main demographic facts and projections for Austria. In the simulations, we rely on data and scenarios from Statistik Austria for fertility, mortality and migration evolutions between 2010 and 2075 and consider five demographic scenario: main scenario, high migration, low migration, high fertility and high skill migration. The *main scenario* takes the main predictions for fertility, mortality and migration flows from Statistik Austria. The *high* (respectively, *low*) *migration* scenario takes the high (respectively, low) migration flow predictions from Statistik Austria. The *high fertility scenario* considers fertility flows which are midway between the standard and the high fertility scenarios from Statistik Austria. The resulting increase in fertility is an average of 25%, depending on the age class[12]. The *high skill migration* assumes that 5% (in pp) of low skill migrants to Austria are replaced by 5% (in pp) of high skill migrants.

Although it is possible to simulate the effect of the same policy reform on different demographic scenarios, we will present the effect of policy reforms only for the main scenario, in the interest of space.

Population aging puts pressure on the retirement pension system. Reforms of the pension system come at strong political costs, if they are implemented at all. Retirement ages are increased, but rarely as fast as the longevity increases. One of the biggest impacts of population aging is thus on the financial sustainability of the pension systems. The main outcome variable that we will consider is thus the social security deficit. Another big impact of aging is changes in health expenditures, since those are increasing with the age of the ill. We will thus look at the financing deficit of the entire social security system, comprising retirement pensions, disability benefits, unemployment insurance and health insurance, and also at the financing deficit of the sole retirement pensions.

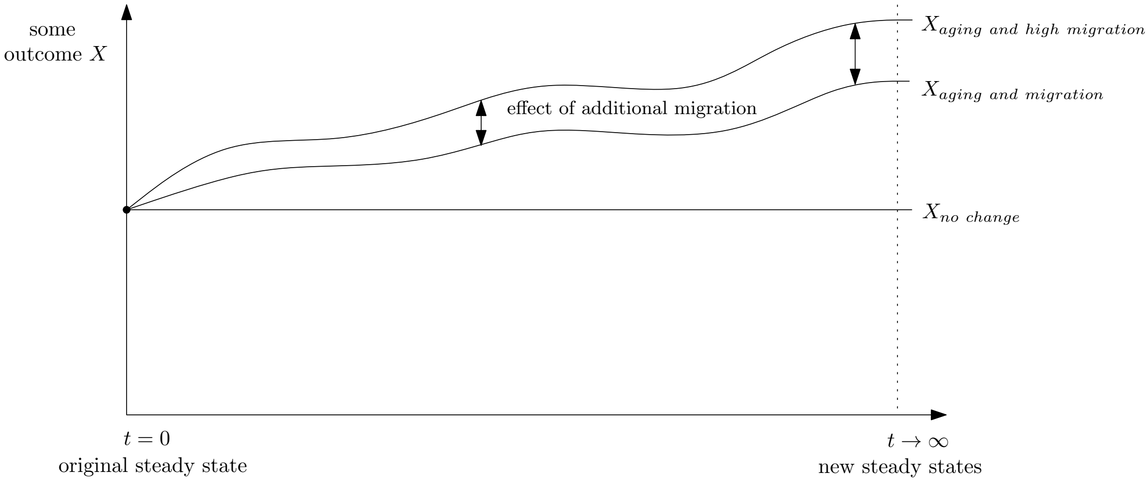
Financing social security, and retirement pensions in particular, is partly done on labor (income taxes and social security contributions). Reducing social security deficits by increasing revenue is a dis-incentive to provide labor along several margins. We will thus look at the labor supply behavioral response of policy reforms, looking at the effective retirement age or participation margin, the average hours of work by worker and unemployment. Changes in labor supply and savings decisions affect production too, so we will also consider the per capita effect on GDP.

One can not measure directly the effect of migration on the financing of social security and other economic outcomes. Indeed, even without migration, population aging prevents the demographic situation to be in a steady-state. To measure the effect of migration in our equilibrium model, one thus needs to compare the outcome value of interest along the transition path when there is a given level migration and when there is another level of migration, as illustrated in figure 5. Alternatively one could compare a given migration scenario with no migration at all. We will

[12]We have deviated from the Statistik Austria scenario for the following reasons: fertility variations relate directly to behavior while migration flows depend significantly on policy; a 50% increase in fertility, the high fertility scenario of Statistik Austria, is a strong shift in behavior unrelated to policy; we focus our analysis on policy reforms and not on changes in individual preferences.

compare the medium level migration projections with the high migration scenario from Statistik Austria, the later having 25% more migration in average.

Figure 5: Idea of effect identification



In the next subsection we present the calibration. It is followed by the simulation results for demographic scenarios. The following subsection presents results for policy reforms. The final subsection summarizes the main findings of the simulations.

5.1 Calibration

This section describes the calibration of the model for Austria. 2010 was chosen as basis year. As the calibration of the full scale model is quite involved we mainly focus on the changes that where made in comparison to Berger et al. (2009), who provide a full documentation of the calibration procedure. Next to the three skill classes we chose eight age groups, i.e. $A = 8$, where age group five is the retirement age group, i.e. $a_r = 5$. Given the distinction between natives and foreigners this amounts to 48 groups. We normalize the population of age over 15 to 100 in the basis year which gives the age distribution contained in table 2.

Table 2: Age structure of the Austrian population in 2010

	natives	foreigners
15 to 19 years	6.32%	0.65%
20 to 24 years	6.27%	1.02%
25 to 39 years	19.33%	4.18%
40 to 54 years	25.19%	2.91%
55 to 69 years	18.08%	1.54%
70 to 79 years	8.53%	0.31%
80 to 84 years	2.98%	0.07%
85 years and more	2.57%	0.05%
	89.27%	10.73%

Source: Statistik Austria.

The definitions of *native* and *foreigner* are based on having or not having the Austrian citizenship. In principle another, more economically relevant criterion would be preferable. As the household side of the model has to be calibrated using such different individual micro-data sources as the Labour Force Survey (LFS) and the Community Statistics on Income and Living Conditions (EU-SILC) the citizenship provides a reliable criterion for distinction. For the simulations we use an assimilation rate of $\zeta = 0.5$, which implies that on average after two generations immigrated foreigners are indistinguishable from natives. The assimilation rate is therefore interpreted as a pure economic measure which does not have to coincide with the probability of receiving the Austrian citizenship. Comparing the age structure of the stock (table 2) with the net inflow (table 1) of foreigners reveals that immigrants are younger. The skill structure is taken from the Labour Force Survey as shown in table 3. Low skill is defined as having attained the highest level of eduction below upper secondary (ISCED 0-2), i.e. individuals without '*Matura*'. Medium skilled individuals have completed upper secondary education (ISCED 3-4), while high skilled hold an academic degree (ISCED 5-6). The skill distribution of foreigners is more disperse, with more low- and high- but less medium-skilled. Due to lack of information we impute the current skill structure for future migrants.

Table 3: Skill structure of the Austrian population in 2010

	low	medium	high
natives	25.50%	60.22%	14.28%
foreigners	36.67%	46.37%	16.96%

Source: Labour Force Survey.

In Berger et al. (2009) the calibration of the model for the households (e.g. age-dependent productivity) is done using disaggregated data at the micro level. In this paper the exact same procedure was simply repeated for the two subpopulations: natives and foreigners. The reader is referred to Berger et al. (2009) for more details on that part of the calibration. A general problem using an equilibrium model is that simulations have to start in a steady state, but the demographic structure from 2010 is not a stationary distribution. For the mortality, migration, and fertility rates observed in 2010 the stationary distribution would be much more concentrated at high age groups. The question is how to find an initial equilibrium when aging is an ongoing process. In principle one has to compromise between two targets. On one hand one can fit the observed demographic transition rates which will give more realistic individual decision making but as argued before comes at the cost of implying a equilibrium population which is considerably older than actually observed in 2010. In this case some macro aggregates like pension expenditures cannot be fit to the data. On the other hand one could target the current population structure by adjusting the demographic transition rates, e.g. by increasing the mortality rates which will allow to fit observed social security expenditures and revenues but will also lead to wrong household decisions because people would have a too short life cycle. We do not compromise between those two approaches by making use of *proxy-migration* to tackle this issue. This means that we use the observed demographic transition rates and change migration flows in the calibration period such that we precisely match the actual demographic distribution. As the probability of migrating does not influence the behavior of the households there is no mistake in individual decision making. The simulation then starts in 2011 where the system is shocked by using the actual forecasted migration flows instead of the proxy-migration.

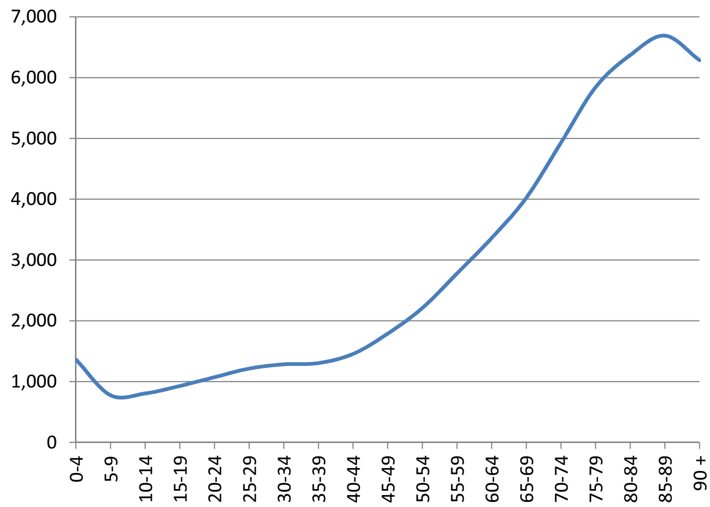
Figure 5 shows the use of different demographic scenarios in our simulation. We take the main

Statistik Austria scenario, covering changes in mortality, fertility and migration, as our benchmark scenario. When simulating a different scenario, say higher migration, we infer the economic impact from the difference between the high migration and the main scenario.

Statistik Austria publishes yearly forecasts in mortality rates for each age. We aggregate them accordingly for our age groups, such that within an age group the mortality rate is constant. The same is done for the age-dependent forecast for fertility rates. These are additionally adjusted to reproduce the predicted amount of newborns, since the model does not distinguish between men and women. Due to lack of data we assume that fertility rates do not differ between skill group and nationality. Statistik Austria only reports forecasts for immigration and emigration. We assume that those flows have the same nationality, age and skill structure as in 2010 which allows to produce net migration flows per age-skill-nationality cell. Using this approach the model can almost perfectly match the forecasted age structure, where the only discrepancy comes from imprecisions through aggregation into age groups and the fact that age groups are of different size.

One important difference to Berger et al. (2009) is that health costs are modeled by taking the age profile into account. Figure 6 reports the age-related public expenditure on health per capita. Clearly, health expenditure are not equally distributed over the life cycle. We convert the profile into weights and distribute aggregate health expenditures over the population. Hence, even for a stable but aging population total health expenditures will increase. This treatment of health expenditure should be interpreted as a lower bound because we have to assume that the age profile given in figure 6 is constant over time, due to the lack of reliable long-term forecasts[13].

Figure 6: Age-related public expenditure on health per capita in EUR for Austria 2007



Source: Data from IHS HealthEcon also presented in Czypionka et al. (2011).

The key elasticities for the behavior of the households in the labor market are summarized in table 4. Here we do not distinguish between nationalities nor age. However, we match the actual hours worked and participation per group by adjusting the age- and nationality-dependent shift parameter in the disutility cost functions $\varphi(\cdot)$.

[13]Czypionka et al. (2011) show that the age profile for health costs has not been stable over the last couple of years and tends to increase, especially for the old age groups.

Table 4: Summary of used labor market elasticities

	low skill	medium skill	high skill
elasticities of			
- hours worked	0.100	0.090	0.080
- retirement	0.108	0.090	0.050
- participation	0.092	0.085	0.050

A key difference in the labor market outcomes between foreigners and natives is labor income. Table 5 shows a summary of the labor income profiles conditional on participation and employment. The pattern is as expected as income profiles increase in age and skill. Given the observed hours worked one can compute the underlying group-specific productivity parameters $\theta^{a,i,n}$.

Table 5: Summary of labor income profiles conditional on participation and employment

	natives			foreigners		
	low	medium	high	low	medium	high
15 to 19 years	1.000	-	-	0.865	-	-
20 to 24 years	1.110	1.533	-	1.110	1.365	-
25 to 39 years	1.240	1.725	2.525	1.240	1.486	2.457
40 to 54 years	1.409	2.071	3.214	1.409	1.772	2.956
55 to 69 years	1.347	2.036	3.293	1.254	1.606	3.433

Notes: Empty cells indicate the assumption of non-participation during education.
Profiles were normalized using young, low-skilled natives.
Source: Data from EU-SILC for 2010 and own calculations.

Table 3 showed the skill structure of the stock of natives and foreigners in the steady state. We additionally have to make assumptions about the skill distribution of newborns. As net migration flows of natives are small, they hardly have an effect on the distribution of the stock of natives. For foreigners this is not the case. To capture the idea of persistence in the foreigners' skill distribution through inter-generational skill spillovers we use the following skill transition probabilities in order to calibrate $\varphi_A^{i,j}$.

Table 6: Skill transition probabilities for foreigners

		offspring		
		low skill	medium skill	high skill
parents	low skill	0.610	0.350	0.040
	medium skill	0.112	0.709	0.179
	high skill	0.020	0.420	0.560

Source: Own calculations based on data provided in Felderer et al. (2004).

5.2 Demographic scenarios simulation results

Table 7 presents the results for the main demographic scenario, without any policy reforms, at four points in time. We describe and comment the results in details for this scenario. For other scenarios, we will only point to the main differences.

Table 7: Simulation results of the main scenario (001)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.16	33.85	41.86	42.81
Effective retirement age	58.80	58.93	59.14	59.04
Unemployment rate	5.90	5.98	6.32	6.63
Employment (yearly hours per worker)	1587	1583	1573	1565
Effective employment (yearly hours per capita)	815	766	662	642
increase from basis in %				
Labor costs	-	-0.56	-1.41	-2.98
Net wages	-	-0.51	-1.14	-2.53
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.42	-7.94	-11.26
increase from basis in %				
GDP/capita	-	-4.91	-17.74	-21.59
Capital/capita	-	-6.33	-20.00	-24.24
Consumption/capita	-	-7.91	-16.49	-20.71
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.53	18.88	22.94	22.89
Social security deficit	6.82	9.32	16.57	17.47
Social security deficit (constant population)	6.82	8.91	14.69	15.50
Pension deficit	4.57	6.08	10.89	11.36
Pension deficit (constant population)	4.57	5.81	9.66	10.08
Social security ratio: natives	0.72	0.65	0.48	0.46
Social security ratio: foreigners	0.94	0.91	0.69	0.62

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

The population increases by close to 13% in 2050, the share of foreigners reaching 30%[14] in 2070. Population aging is reflected by the dependency ratio, which more than doubles between 2011 and 2070. In 2070, the ratio is higher than 50%, meaning that approximately more than half of the output (income) generated by one worker is used to finance consumption of persons in age of retirement. Even if there are no policy reforms, the current fiscal and pension systems have a (mild) component to stimulates later entry into retirement. The average effective retirement age increases slightly from 58.8 to above 59. Even though taxes are kept constant, population aging puts pressure on the financing of the pension system and the average pension per beneficiary loses 7.9% (in detrended value, that is compared to what the value would be if it had followed the productivity growth rhythm). There is thus less incentive to work and accumulate pension rights over the entire life-cycle and effective employment per worker slightly decreases over time, from an average of 1587 hours per year per worker to 1565 in 2070. The decrease in effective

[14]Recall that this number is not necessarily related to the number of non-Austrian citizens.

employment is more visible when one looks at the effective hours per capita, which decrease by more than 20%. This is due to the increase in life expectancy (moving from about 80.3 to 87.7 years for newborns), being significantly larger than the increase in retirement age. It is thus no surprise that the GDP per capita loses more than 21% (in detrended value) by 2070.

Population aging and migration have significant impacts on the labor market. Combining all margins together, the average working time per capita decline from 815 to 642 yearly hours. The main driver is the combination of aging and retirement decisions.

The decline along the intensive margin (hours per worker) is limited, moving from 1587 to 1565 yearly hours. The overall participation rate among workers of ages 15 to 69 declines from 63.8% to 61.0% (not reported), another relatively moderate decline. The constant inflow of new immigrants increases labor supply but the sluggish response of firms, due to capital adjustment costs, creates a wedge between labor demand and labor supply and raises the unemployment rate. The increase in the unemployment rate from 5.9% to 6.3% thus also contributes to the decline in effective labor supply, but in moderate proportion. Most of the decline however comes from retirement and aging. Intertemporal optimization decisions from households, who balance disutility of labor with added consumption, lead them to delay retirement, without any reform. However, the increase is small: the effective retirement age climbs from 58.8 years to 59.0 years. This decision is partly due to the loss of pensions (-7.9%) relative to productivity growth, which increases the attractiveness of leisure. The pension loss itself is driven by three factors. First, the partial indexation of benefits over the entire-life cycle is only 30% of the wage growth[15]. Hence, pensions decrease in comparison to wages during retirement. As people live longer, pensions on average decrease. Second, pensions are lower because the average wage rate is driven down by the labor supply shock of immigration. Third, there is a composition effect, given the rising share of foreigners, who have worse labor market perspectives and consequently lower pensions. Obviously, this composition effect has no direct effect on the retirement decision. Over this period, life expectancy increases from 80.3 to 87.7 years. Clearly the low increase in retirement age and large increase in life expectancy has a large impact on overall labor supply, as is reflected in the fraction of pensioners in society, increasing from 29% to 43%.

Migration influences education decisions of the native population. Table 8 shows that natives choose to replace high level with medium level education over time. In spite of this decision, the proportion of households with medium level education in the entire population declines. This is driven by immigration, labor demand and net wages variations. Most migrants to Austria have either low or high skills, compared to the natives. This unbalanced increase in labor supply forces firms to offer higher wages to medium skill workers, in order to attract more of them and maintain a production plan with an optimal balance of workers across the skill distribution. The higher increase in wage for medium skill positions tilts natives education decisions towards medium level education. Natives are responding to the inflows of migrants by choosing educations which compensate the relative imbalance in the skill distribution of migrants[16].

The simulation also quantifies the magnitude of the challenge posed by population aging on social security financing. At constant population, the social security deficit without any reforms would rise from the current 6.8% to 15.5% of GDP in 2070, a more than two-folds increase. Focusing on the retirement pension component of social insurances, the deficit rises from 4.6% to 9.7% in

[15]Numerical simulations with twice larger indexation, not reported here, show that the relative loss of pension benefits is reduced to 5.40%.

[16]Simulations assuming exogenous and constant skill decisions by natives confirm that natives decisions are driven by changes in relative marginal product of labor and wages. For instance, net wage changes of natives in 2050 would be -2.8% for low skills, +3.2% for medium skills and -5.7% for high skills. Allowing for endogenous education clearly would push for less high level education.

Table 8: Skill distribution and net wages changes in the main demographic scenario

Skill distribution	Overall 2011	Overall 2050	Natives 2011	Natives 2050	Foreigners 2011	Foreigners 2050
Low	26.7%	27.9%	25.5%	25.5%	36.7%	35.4%
Medium	58.7%	57.7%	60.2%	61.0%	46.4%	47.3%
High	14.6%	14.4%	14.3%	13.4%	17.0%	17.3%

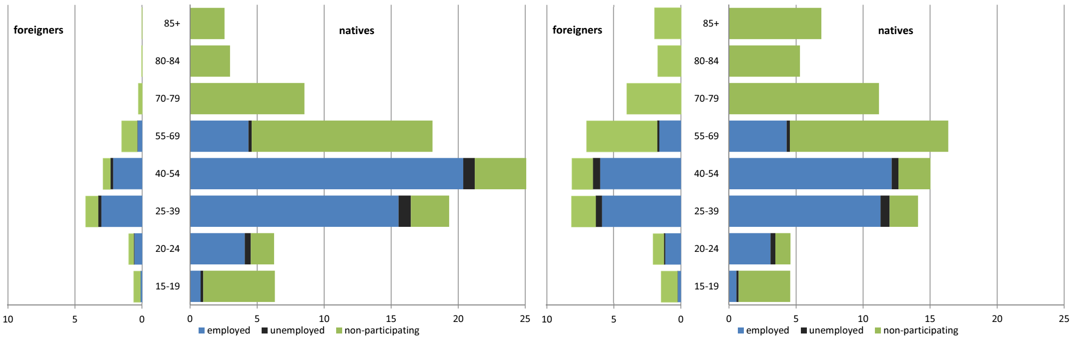
Net wages variations	Overall 2011/2050	Natives 2011/2050	Foreigners 2011/2050
Low	-3.5%	-3.1%	-4.0%
Medium	-0.5%	1.1%	-0.9%
High	0.4%	0.4%	-2.7%

2050 and 10.1% of GDP in 2070, consistent with the 10.1% deficit estimate in 2050 from Jaag et al. (2010). The financing deficit increase both for the entire social security insurance and the sole retirement pension systems. The numbers illustrate the effect of population aging not only on the financing of retirement pensions, but also on financing health insurances[17]. As population ages, the fraction of health expenditures out of total output increases fastest (40% increase in 2070, as opposed to 12% for population and 30% for pension expenditures), since health costs increase with the age of ill households. A first policy implication and a contribution to the literature of this research project is that reforms need to tackle not only retirement pensions, but also health insurance financing to deal with an aging population.

Table 7 also shows that immigration helps but does not solve the social security financing issues. The social security ratio of natives is lower than that of foreigners, indicating that natives draw more out of the social security system than they contribute directly (not taking taxes into account), and even more so than the foreigners. The ratio is also below one for foreigners which means that they also draw more than they contribute. Overall, the average deficit ratio is however higher and more favorable with foreigners. Looking at changes over time, one sees that they decrease for both subpopulations. Aging does not only affect the native population, but also that with foreign background. For instance, the ratio decreases from 0.72 in 2011 to 0.46 in 2070 for natives, and from 0.94 to 0.62 for foreigners. Figure 7 provides a graphical illustration of this analysis, comparing the age structures of each subpopulation in 2011 and in 2070. The fact that foreigners draw less from the social security system in net can be seen from the larger fraction of employed households (blue colored) out of the total population.

[17]Budget balancing rules have an influence on the results, which underestimate the challenge in a more realistic setting. We will come back to this point below.

Figure 7: Demographic structure and labor market outcomes in Austria in 2011 and 2070



Note: Left panel shows 2011, the right panel shows 2070. Numbers are reported in percent of the population of 15+ year old in 2010. Source: Statistik Austria and simulation results.

Table 9 presents the simulation results for the high-migration scenario, still without policy reform.

Table 9: Simulation results of the high migration scenario (020)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	105.69	118.78	121.94
Share of foreigners	10.73	14.75	27.22	34.21
Dependency ratio	26.66	33.01	48.64	50.86
Pensioners (in % of population)	29.16	33.57	40.92	41.78
Effective retirement age	58.80	58.92	59.13	59.11
Unemployment rate	5.90	6.00	6.42	6.58
Employment (yearly hours per worker)	1587	1582	1570	1562
Effective employment (yearly hours per capita)	815	768	669	652
increase from basis in %				
Labor costs	-	-0.81	-2.16	-2.26
Net wages	-	-0.73	-1.79	-1.73
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.47	-8.81	-12.53
increase from basis in %				
GDP/capita	-	-4.81	-17.45	-20.23
Capital/capita	-	-6.36	-19.90	-22.35
Consumption/capita	-	-7.01	-15.55	-17.95
in % of basis GDP				
Health expenditure	7.96	8.92	11.40	11.89
Pension expenditure	17.53	18.89	23.34	23.75
Social security deficit	6.82	9.21	16.48	17.40
Social security deficit (constant population)	6.82	8.71	13.87	14.27
Pension deficit	4.57	5.97	10.64	11.05
Pension deficit (constant population)	4.57	5.65	8.96	9.06
Social security ratio: natives	0.72	0.65	0.49	0.48
Social security ratio: foreigners	0.94	0.94	0.73	0.65

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Not surprisingly, the size of the population is larger than in the main scenario, increasing by almost 22% in 2070 compared to less than 13%. The share of foreigners is also larger. Since migrants arrive at a relative young age, the dependency ratio is lower, at 50.8% rather than

52.8%. This should translates into lower pension and social security deficits. It is indeed the case: in constant population terms, the deficits in 2070 are 9% and 14.3% of GDP in the high migration case, compared to 10% and 15.5% in the main scenario. Some might have expected a larger effect of migration on deficit reduction. The reason for a moderate effect is that migrants also age and rely on retirement pensions.

One can also note that the loss of GDP per capita (compared to the productivity growth trend) is lower in the high migration scenario, at 20.2% versus 21.6%. This outcome is driven by labor supply effects, as the participation rate in the high migration case is higher (44.6% versus 43.9%, which translates into a 652 work hours per capita versus 642). One explanation for this difference is that immigrants are younger in relative terms so the average dependency ratio is lower, meaning that there are more people in working age.

We compared the effect of higher migration with standard retirement policy reforms. Specifically, we simulated the effect of an increase in retirement age under the main demographic scenario so that the social security deficit (in constant population terms) is equivalent to the deficit in the high migration scenario, that is 13.87% of GDP in 2050. We did the same experiment separately of reducing pension benefits and increasing social security contributions. The result is as follows: an increase in migration flows into Austria (of about 25%) leads to the same deficit reduction by 2050 as an effective increase of retirement of 1 year, or an average decrease of retirement pensions of 11.3% (rather than the 7.9% due to population aging), or an average increase of social security contributions of 6.7%. These experiments show that the effect of migration, although not large, can not be considered small either. Details on these experiments are included in subsection 5.3.

Table 10 presents the results for the low migration scenario without policy reforms. Results are symmetric to the high migration scenario.

Table 10: Simulation results of the low migration scenario (103)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	103.69	106.83	103.45
Share of foreigners	10.73	13.42	21.31	26.76
Dependency ratio	26.66	33.78	52.79	55.23
Pensioners (in % of population)	29.16	34.13	42.90	43.75
Effective retirement age	58.80	58.93	59.17	59.15
Unemployment rate	5.90	5.95	6.16	6.34
Employment (yearly hours per worker)	1587	1583	1576	1572
Effective employment (yearly hours per capita)	815	764	655	639
increase from basis in %				
Labor costs	-	-0.31	-0.39	-1.11
Net wages	-	-0.28	-0.22	-0.80
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.38	-7.02	-9.71
increase from basis in %				
GDP/capita	-	-4.98	-17.87	-20.71
Capital/capita	-	-6.31	-19.85	-22.49
Consumption/capita	-	-8.51	-16.36	-19.24
in % of basis GDP				
Health expenditure	7.96	8.83	10.54	10.37
Pension expenditure	17.53	18.87	22.54	21.92
Social security deficit	6.82	9.44	16.64	16.83
Social security deficit (constant population)	6.82	9.10	15.57	16.27
Pension deficit	4.57	6.19	11.12	11.18
Pension deficit (constant population)	4.57	5.97	10.41	10.80
Social security ratio: natives	0.72	0.64	0.48	0.46
Social security ratio: foreigners	0.94	0.88	0.65	0.60

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 11 contains the results of the simulation for the high fertility scenario. The positive impact of higher fertility takes time to materialize: the dependency ratio improves to 49.9% in 2070 (compared to 52.8% in the base demographic scenario) but the difference is smaller in 2050 (49.2% versus 50.6%). Consequently, the improvement in financing of social insurances are largest by 2070. Then, the pension deficit in constant population terms goes down from 10.1% for the base scenario to 8.5% under high fertility. The reason for such an improvement is mechanical, in the sense that higher fertility compensates for the increase in life expectancy and reduce the speed of population aging[18].

[18]A simulation of even higher fertility, taking 100% of the high fertility scenario from Statistik Austria instead of 50%, leads to similar results for the given time horizon. For instance, in 2070, the pension deficit (in constant population) is 8.31% instead of 8.45%. Benefits are larger for longer time horizons.

Table 11: Simulation results of the high fertility scenario (022)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	114.99	118.42
Share of foreigners	10.73	14.09	24.17	29.90
Dependency ratio	26.66	33.39	49.20	49.89
Pensioners (in % of population)	29.16	33.85	41.09	40.90
Effective retirement age	58.80	58.93	59.16	59.35
Unemployment rate	5.90	5.97	6.31	5.99
Employment (yearly hours per worker)	1587	1583	1571	1552
Effective employment (yearly hours per capita)	815	766	665	661
increase from basis in %				
Labor costs	-	-0.54	-1.57	1.57
Net wages	-	-0.48	-1.27	1.95
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.42	-7.93	-11.40
increase from basis in %				
GDP/capita	-	-4.81	-17.48	-17.27
Capital/capita	-	-6.30	-19.73	-17.04
Consumption/capita	-	-6.89	-14.62	-12.07
in % of basis GDP				
Health expenditure	7.96	8.88	11.11	11.51
Pension expenditure	17.53	18.88	22.96	22.94
Social security deficit	6.82	9.32	16.38	15.78
Social security deficit (constant population)	6.82	8.90	14.24	13.33
Pension deficit	4.57	6.08	10.67	10.00
Pension deficit (constant population)	4.57	5.80	9.28	8.45
Social security ratio: natives	0.72	0.65	0.49	0.52
Social security ratio: foreigners	0.94	0.91	0.70	0.66

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 12 presents the result for the high skill migration scenario with no policy reform. Compared to the main migration scenario, the effects are almost identical. GDP per capita indeed grows more but the 2070 social security deficit is only reduced from 15.5% to 15.4%. Higher skill migration increases the average productivity. As expected, the GDP per capita deviation from trend is lower than in the main case (-17.3% instead of -21.6% in 2050). However, high skill workers in general receive higher pension benefits, as these are tied to the earnings history. This explains why the social security deficit is not reduced much. Izquierdo et al. (2010) also finds a low impact of skill content on public finances in Spain. On the other hand, Storesletten (2000) finds strong impacts of the skill content of migration in the US. The difference in results may be due to the fact that social security benefits in the US are regressive, so less pensions need to be paid to high skill migrants.

Table 12: Simulation results of the high skill migration scenario (025)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.16	33.83	41.80	42.72
Effective retirement age	58.80	58.94	59.19	59.11
Unemployment rate	5.90	5.95	6.23	6.50
Employment (yearly hours per worker)	1587	1583	1574	1565
Effective employment (yearly hours per capita)	815	766	665	646
increase from basis in %				
Labor costs	-	-0.50	-1.10	-2.46
Net wages	-	-0.44	-0.79	-1.97
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.37	-7.67	-10.78
increase from basis in %				
GDP/capita	-	-4.71	-17.02	-20.61
Capital/capita	-	-6.01	-18.89	-22.80
Consumption/capita	-	-7.64	-15.77	-19.64
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.53	18.88	22.98	22.96
Social security deficit	6.82	9.30	16.49	17.37
Social security deficit (constant population)	6.82	8.89	14.62	15.41
Pension deficit	4.57	6.07	10.85	11.32
Pension deficit (constant population)	4.57	5.80	9.62	10.05
Social security ratio: natives	0.72	0.65	0.48	0.46
Social security ratio: foreigners	0.94	0.92	0.71	0.63

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

5.3 Policy reforms scenario

An overview of the simulation results of a selection of policy reforms can be found in table 13. Complete results by policy can be found in appendix A. For comparison purposes, we include the simulation results of the demographic scenarios as well as the initial steady-state values (in 2010).

Table 13: Overview of selected simulation results (year 2050)

	Scenario	Effective age retirement	Social security contrib. (Δ%)	Pension per benef. (Δ%)	Employment (h/worker/year)	GDP/capita (Δ%)	Pension deficit (% GDP_0)	Social security deficit(% GDP_0)
Initial steady-state (2010)		58.83	0.00	0.00	1587	0.00	4.54	6.79
Demographic scenarios (2050)								
001	Main (Stat AT)	59.14	0.00	-7.94	1573	-17.74	9.66	14.69
020	High migration (Stat AT = ca.+25%)	59.13	0.00	-8.81	1570	-17.45	8.96	13.87
103	Low migration (Stat AT = ca.-25%)	59.17	0.00	-7.02	1576	-17.87	10.41	15.57
022	High fertility (50% Stat AT)	59.16	0.00	-7.93	1571	-17.48	9.28	14.24
025	Higher skill migration (5% $L \rightarrow H$)	59.19	0.00	-7.67	1574	-17.02	9.62	14.62
024	High prod. growth (1.5% → 2.25%)	59.42	0.00	-17.85^2	1573	-17.60^2	7.36	12.40
Policy reforms: main instruments (2050)								
150	Lower pension benefits (-0.6% GDP)	59.24	0.00	-11.24	1573	-17.54	8.84	13.89
152	Higher contributions (+1.3% GDP)	59.02	6.70	-8.73	1571	-18.65	9.09	13.89
151	Higher retirement age (+1.4 years)	60.17	0.00	-6.15	1570	-14.41	8.95	13.83
054	Combined (150+152+151)	60.16	6.70	-10.26	1567	-15.09	7.56	12.19
160	Lower pension benefits (-3% GDP)	59.57	0.00	-24.71	1569	-16.90	5.64	10.71
008	Higher contributions (+3% GDP)	58.85	15.46	-9.76	1567	-19.89	8.38	12.90
019	High retirement age (+3 y over 40)	61.66	0.00	-5.05	1563	-11.53	7.79	12.54
055	Combined (160+008+019)	62.05	15.46	-23.62	1552	-12.21	2.51	6.70
011	Lower pension benefits (-5% GDP)	59.80	0.00	-36.18	1567	-16.54	3.01	8.12
203	High ret. age, phase-in (+5 y over 40)	63.39	0.00	-6.20	1554	-7.31	5.89	10.45
207	High ret. age, phase-in (+9 y over 40)	66.68	0.00	-6.03	1528	1.63	2.62	6.78
Policy reforms: other instruments (2050)								
003	Pensions inflation indexation	59.24	0.00	-10.28	1572	-17.63	9.10	14.14
007	High penalty early ret. (corr. 5.2%)	60.09	0.00	-7.85	1570	-15.19	8.74	13.66
013	High ref. year (corridor 62.5 → 65.5)	59.20	0.00	-10.42	1573	-17.68	9.10	14.14
044	SS budget balance with SSC	56.91	102.81	-12.87	1541	-31.05	3.97	6.02
045	High migration, SS budget bal. SSC	57.22	94.13	-13.20	1541	-29.24	3.59	5.72
Methodology evaluation (2050)								
301	Non-age dependent health costs	59.14	0.00	-7.94	1573	-17.52	9.66	12.80
350	Exogenous retirement decisions	58.79	0.00	-8.43	1574	-18.77	9.91	14.99
351	Exo. retirement, high migration	58.79	0.00	-9.27	1571	-18.44	9.20	14.17
352	Exo. retire., lower pens. (-3% GDP)	58.79	0.00	-25.89	1571	-19.15	6.08	11.26
355	Exo. retire., lower pens. (-0.65% GDP)	58.79	0.00	-12.22	1574	-18.85	9.08	14.18

Notes: (1) Pension deficit and social security deficit in constant population terms (2) numbers not comparable, since they are deviations from productivity growth trend.

The table shows that the only policy reforms which are successful in containing the social security deficit are 8 years increases in effective retirement age or a combination of medium to strong reduction in public pensions, increase in contributions and effective retirement age. The pension reduction is an ex-ante reduction of benefits corresponding to an aggregate reduction of 3% of GDP, leading ex-post to an average of almost 25% reduction in pension payments compared to the productivity growth trend. The increase in contributions is an ex-ante increase amounting to 3% of GDP, leading to an ex-post average increase higher than 15%. The increase in retirement age is an ex-ante increase of 3 years phased-in over 40 years, with an ex-post effective increase of 2.5 years[19]. This combined reform (055) would lead to a pension deficit cut from 4.5 to 2.5% of GDP (in constant population) and total social security benefits essentially kept constant at 6.8%. An increase in 8 years of effective retirement age (207) would achieve the same deficit reduction but also increase output beyond productivity trend.

Other policy reforms from this selection which are successful at containing the pension deficit are either not successful at containing the total social security benefits (011; strong pension benefit reduction) or adjust social security contributions at every period (044, 045; more on these below).

All of the policy reforms presented in the table have the intended effect of reducing social security deficit. Some policies however impose a higher penalty on economic growth. From those policies which achieve the same social security deficit target as higher migration (150, 151, 152), an increase in contributions leads to a loss of 18.6% of GDP per capita growth (compared to the productivity growth level) while an increase in the effective retirement age leads to a loss of less than 14.5% of GDP. Lower pension benefits lead to an intermediate value. This is a general pattern: amongst single instrument policy variations, higher contributions are the most damaging to economic growth and later retirement age the least.

The phased-in 4.3 years increase of the retirement age over 40 years corresponds approximately to a 2/3 rule of life (reform 203): for every increase in life expectancy of 1 year, the retirement age should increase by 0.66 year, taking a work life of 40 years and a rough average retirement life of 20 years; under the main demographic scenario, life expectancy increases from about 81 to about 88 years; the 7 years life expectancy increase is associated with a gradual increase of 4.7 years in the retirement age, comparable to 4.3. The simulation shows that the 2/3 rule of thumb is roughly successful at containing the pension deficit, but not the total social security deficit, due to health expenditure increases.

If one wanted to devise a rule of thumb to contain total social security deficit, one would need to increase retirement age by more, namely an effective increase of 7.8 years (case 207). This would correspond to a 8/7 rule of thumb, another illustration of the impact of population aging when health expenditures are age-dependent. Yet another illustration of the importance of these costs is the estimation of public finance deficit assuming that health expenditures are not age-dependent (case 301), a counterfactual experiment. By 2050, the total social security deficit would reach 12.80% of GDP, a difference of close to 2% of GDP with the more realistic assumption of age-dependent expenditures (main scenario). The bias in estimating social security deficit increases, introduced by assuming flat health expenditures, is thus close to 25%, a significant number[20].

Retirement pensions can be reformed with other instruments. Indexing pension benefits fully on inflation rather than partially on wages (reform 003) yields similar results as a light pension

[19] Ex-ante refers to ceteris paribus changes, before taking behavioral responses into account, which we refer to as ex-post.

[20] As immigrants are younger in average and health expenditures increase with age, one would expect that higher immigration increase even more the bias. Numerical simulation (not reported here) confirm this expectation, but to a very small extent.

benefit reduction (reform 150). Higher penalties for early retirement (reform 007) or a higher reference year for the calculation of rights in the pension corridor (reform 013) have similar effects as a direct increase in the retirement age (reform 152), with different magnitudes.

Simulating the impact of higher productivity growth (reform 024) illustrates how critical the overall health of the economy is. Without any reform, an increase of 50% of the growth rate would have a larger pension deficit reduction effect than a 2.5 years effective increase in the retirement age (reform 019).

The last group of simulations in table 13 evaluates the impact of more realistic modeling features, rarely found in previous analyses of the role of population aging and migration. The main novelties of the model are age-dependent health expenditures, endogenous retirement decisions and endogenous human capital formation. We discussed the bias created by taking age-invariant health expenditures above. Simulations show that exogenous and constant human capital distribution leads to similar predictions of public finance deficits and other aggregate outcomes. Subsection 5.2 however discussed skill composition effects and hinted at different distributional consequences when one considers exogenous or endogenous education decisions.

There is also a bias when considering exogenous retirement decisions. The magnitude of the bias depends on which approach is used to assess the role of migration. The literature has quantified the effect of immigration on public finances in essentially two ways, either by evaluating what reforms would be needed to achieve the same deficit reduction as a given immigration increase or by direct simulation and projection of the deficit. We provide simulation results for both approaches. Storesletten (2000) uses the first approach and finds that a 40% increase in high skill migration would lead to the same reduction as an increase of 16% in income taxes. Our simulations show that the high migration scenario of Statistik Austria would deliver the same deficit reduction as an average additional cut of pension benefits of 3.3% (11.2% loss in case 160 rather than 8% in case 001). If one assumes exogenous retirement decisions, the deficit reduction would correspond to an additional cut of pension benefits of 3.8% (12.2% loss in case 355 rather than 8.4% loss in case 351). The 3.8% versus 3.3% bias of using constant retirement age is significant. Exogenous retirement decisions thus overestimate the benefit of immigration.

The bias is also large when evaluating the effect of reforms under demographic changes. A moderate to large reduction in pension benefits would move social security deficit in 2050 from 14.7% to 10.7% of GDP under endogenous retirement decisions, a 50% lower increase of deficit from 2010 to 2050 (cases 001 versus 160). The same reduction in pension benefits under exogenous decisions would move deficits from 15.0% to 11.3%, a 45% lower increase of deficit (cases 350 versus 352). Exogenous retirement decision thus underestimate the benefit of pension reduction, predicting a 45% gain while the gain is 50% with endogenous retirement decisions. The reason is that intertemporal optimization retirement decisions, balancing disutility of delayed retirement with loss in purchasing power due to lower pensions, lead households to delay retirement, an additional benefit to pension cuts when it comes to pension financing. Endogenous retirement decisions are thus important when one evaluates the effect of reforms and demographic changes on social security financing, whether these changes involve migration or not.

One critical choice of the simulations is the policy instrument to close the government budget. In the simulation, lump-sum taxes are changed in every period so that the government debt is kept constant (in detrended terms), covering possible deficits from the social security budget. Alternative choices could be labor income taxes or social security contributions. One can also decide to balance the social security budget and the overall government budget with different instruments. In this case, the social security deficit is kept constant with one instrument (say social security contributions) and the overall government budget is kept constant with another instrument (say lump-sum taxes).

The reason for choosing lump-sum taxes for closing the overall government budget is that we want to isolate the effects of population aging and migration. Using social security contributions or income taxes modifies the labor supply behavior of households, so a closing instrument different than lump-sum taxes would superimpose tax distortion effects to demographic effects. On the other hand, closing the budget with lump-sum taxes carries a significant cost. The approach underestimates the pragmatic effect of demographic changes. Indeed, using lump-sum taxes for revenue generation is unrealistic and government use them primarily as redistribution schemes, for instance for family subsidies. Government therefore rely on other taxes and contributions to raise revenue in reality.

To quantify the extent of the pragmatic underestimation which comes with choosing lump-sum taxes, we have run simulation with more realistic budget closing instruments. Table 14 presents the result of balancing at every period the social security budget with contributions so that it remains constant, without any additional policy reform. While the deficit is constant at 6.8% (in actual population terms; 6.0% in 2050 in constant population terms), social security contributions doubles, decreasing labor supply incentives. For instance, the working hours per capita reduce to 557 in 2050, compared to 662 when lump-sum taxes are used (see table 7). As a consequence, detrended GDP per capita is reduced by more than 30% when closing with contributions as opposed to less than 20% when closing with lump-sum taxes. One should keep in mind this gap for policy advice when using the policy reforms comparison in table 13.

Table 14: Simulation results of the main scenario with budget closing SSC (044)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.21	34.82	45.01	44.97
Effective retirement age	58.76	58.26	56.91	57.48
Unemployment rate	5.97	6.81	9.84	10.00
Employment (yearly hours per worker)	1589	1577	1541	1528
Effective employment (yearly hours per capita)	814	735	557	552
increase from basis in %				
Labor costs	-	0.29	2.07	0.09
Net wages	-	-7.45	-26.27	-26.64
Social security contribution	-	26.25	102.81	98.90
Pension payment per beneficiary	-	-1.37	-12.87	-19.99
increase from basis in %				
GDP/capita	-	-9.17	-31.05	-32.77
Capital/capita	-	-10.00	-32.74	-35.00
Consumption/capita	-	-15.06	-28.66	-32.41
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.56	19.43	23.39	21.69
Social security deficit	6.79	6.79	6.79	6.79
Social security deficit (constant population)	6.79	6.49	6.02	6.03
Pension deficit	4.55	4.55	4.48	3.81
Pension deficit (constant population)	4.55	4.35	3.97	3.38
Social security ratio: natives	0.72	0.74	0.75	0.74
Social security ratio: foreigners	0.94	1.04	1.08	0.97

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

5.4 Comparison with literature results

We compare our results with similar exercises in the literature.

Storesletten (2000) compares reforms that are needed to maintain the sustainability of social security in the US, taking into account population aging and current migration flows. He finds that a 40% increase in highest skill migration (high skill adults aged 40-44) would lead to the same result as an increase of 16% in income taxes (from 0.282 to 0.326), both reforms delivering sustainability. We find that with our main migration scenario, social security contributions need to increase 103% between 2010 and 2050 to maintain total social security deficit constant (case 44), while the increase is only 94% for the high migration scenario, which corresponds to 25% more migration that in the main scenario and 8% lower contributions (case 45). In spite of the differences of the analysis (Austria; average skill migration; endogenous retirement decision), the similarity of the quantitative results is remarkable.

Fehr, Jokisch and Kotlifoff (2003) and Borgy, Chojnicki, Le Garrec and Schwellnus (2009) use general equilibrium models with several regions of the world and population aging. The first paper uses exogenous migration flows, endogenous intensive labor supply decisions and exogenous retirement dates. The second analysis uses endogenous migration flows and exogenous labor supply decisions. They both compare the change in tax (and social security contributions) rates which are necessary to keep the government budget balanced. Fehr, Jokisch and Kotlifoff (2003) find that total rates in Europe should increase from 0.40 to 0.69 between 2000 and 2050 with current immigrations while they only need to increase to 0.66 with doubling immigration, respective increases of 71% and 64%. In other words, an increase of 100% of immigration would lead to a public finance gain of about 10% (elasticity: 0.1). Borgy, Chojnicki, Le Garrec and Schwellnus (2009) compare United Nations exogenous migration flows projections and endogenous flows, which turn out to be 170% larger. Contributions increases from 0.17 to 0.28 under exogenous flows and to 0.255 with endogenous migration flows, respective increases of 64% and 50%. In other words, an increase of 170% of immigration would lead to a public finance gain of about 23% (elasticity: 0.14). In comparison, we find that an increase of 25% of migration leads to gain of about 8% in public finance (elasticity: 0.32). One explanation for the larger elasticity that we find are age-dependent health expenditures, which magnifies the impact of population aging on the financing of total security insurances in our analysis. Since immigrants are younger in average, more immigration does not only help reduce the dependency ratio but also reduces the impact of aging on health expenditures and thus social security finances. Overall however, estimates are close.

In their general equilibrium analysis of immigration and population aging in Spain, Izquierdo, Jimeno and Rojas (2010) focus on skill differences between immigrants and natives. They find that the pension deficit would rise from 0% in 2000 to 15% of GDP by 2050 with no immigration and to 5% with current immigration projections, whatever the skill composition of the flows. We find that the deficit would be 1% higher if migration was only 50% less than the main scenario projections (pension deficit of 10.7% of GDP instead of 9.7%) and that skill composition of migration has a small effect (case 025). Impacts of migration found by Izquierdo, Jimeno and Rojas (2010) are thus larger than the impacts that we find and even larger than the one found by Fehr, Jokisch and Kotlifoff (2003) and Borgy, Chojnicki, Le Garrec and Schwellnus (2009). One possible explanation is that there was a large increase in immigration flows in Spain in the early 2000s, at around the time of the 0% deficit benchmark in 2000.

The goals of the analysis performed by Mayr (2005) are the closest to ours but the tools are different. Using a generational accounting approach, she finds that an increase of around 40% of migration would reduce the intertemporal public liabilities (IPL) from 167.5 % to 163.8 % of GDP, a 2.2% decrease. This aggregate level estimate takes into account demographic changes but not age-dependent social security expenditures so we compare it with variations in pension deficit at actual population size (not constant population size, which is a per capita measure). In our main demographic scenario pension deficit rises to 10.9 % of GDP in 2050 while 25% more migration would lead to a deficit of 10.6% and 50% more migration to a deficit of 10.5%, respective drops of 2.2% and 3.0%. Neglecting the fact that a dynamic indicator (IPL) can not be compared to a static indicator (deficit in % of GDP) in the two studies a 40% increase in migration leads to improvements of social security financing in the regions of 2.2 to 2.5%, another remarkable result.

Although Jagg, Keuschnigg and Keuschnigg (2010) do not evaluate separately the impact of migration, their general equilibrium analysis of the effect of population aging in Austria is an interesting benchmark. Their analysis indeed contains similar endogenous labor supply decision margins, including hours and retirement. Under their base scenario analysis, population would increase 10% between 2010 and 2050, the fraction of pensioners in the population would increase by 53%, GDP per capita would be 18.4% lower than the productivity growth trend and the pension deficit would reach 10.1% of GDP. The pension reform that they consider has several components and would encourage later retirement so that the fraction of pensioners would only represent a 46% increase and the pension deficit would decrease to 8.0% of GDP. Under our main demographic scenario, we find that population would increase 13% between 2010 and 2050, the fraction of pensioners would increase by 44%, GDP per capita would be 17.8% lower and the pension deficit would reach 10.9% of GDP. Our combined pension reform (054) considers different policy margins but would also achieve a reduction of the pension deficit to 8.5% of GDP and would encourage later retirement so that the fraction of pensioners only increases by 39%. Overall again, results are close.

The other general equilibrium analysis of migration, aging and public finance mentioned in section 2 can not be compared with our simulations. Indeed, they either have no quantitative analysis or contain numerical simulations which are not calibrated and serve as illustrations.

In spite of the differences in model characteristics and datasets, our simulation results are comparable to results found previously in the literature. Sometimes, similarities are striking.

5.5 Main findings from the simulations

The first main overall finding of the simulations is that the effect of aging on the social security finances is different if health insurances are taken into account or not. In the main demographic scenario, the overall social security deficit rises from 6.8% in 2010 to 14.7% of GDP in 2050, while the retirement pension deficit alone rises from 4.5% to 9.7% of GDP. The difference comes from the financing of health expenditures, which increase from 8% to 11% of GDP over the same period. Accurate modeling of health expenditures variation is still an active area of scientific research and our simulations also show its importance: unrealistic modeling with health expenditures that are constant over the life-cycle (as opposed to age-dependent) would underestimate by close to 25% the increase in deficit due to demographic changes.

The second main overall finding is that migration helps to reduce the social security deficit in a moderate fashion, without completely reducing it. Higher migration (about 25% larger than the main scenario) would improve the dependency ratio in 2050 from 50.6% to 48.6% but migrants also age. As a result, the total social security deficit would only be reduced to 13.9% of GDP in 2050. To attain a similar social security deficit without additional migration, the effective retirement age would have to be raised by 1 year, average social security contributions increased by 6.7% or average pension benefits reduced by 11.2% (rather than the mechanical decrease of 7.9%).

The third main finding is methodological. Taking constant retirement age introduces a bias in evaluating migration and pension reform effects. For instance, the average pension benefits would have to be cut by 12.2% to reach the same deficit reduction as higher immigration under constant retirement age, overestimating its benefits. Constant retirement age would also underestimate the benefit of pension reductions, predicting a 45% gain instead of a 50% gain under endogenous retirement decisions.

Other findings include the large financial burden of population aging if no reforms are implemented, the need for moderate to strong multiple pension reforms to maintain social security financing, the lower damage to economic growth of increases in the retirement age, the efficiency of a simple 2/3 retirement age increase rule-of-thumb for pension financing but not for total social security financing , the importance of overall economic health and natives adjustments in education decisions.

Without any reforms and taking the standard fertility, longevity and migration scenarios from

Statistik Austria, our simulations show that the social security deficit would more than double between 2010 and 2050, rising from 6.8% to 14.7% of GDP. Because of the life expectancy mechanical effect and behavioral responses, the decline in labor supply due to population aging leads to a GDP per capita which is 18% lower than what it would be if it grew at the speed of productivity. To isolate the effect of demographic changes, simulations were performed using lump-sum taxes to close the government budget. In reality, such instruments are not available and distortive taxes and social contributions would lead to a higher drag on the economy.

Combined moderate to strong increases in the effective retirement age, reductions in pension benefits and increases in social security contributions would be needed to keep the social security deficit constant by 2050. If the retirement age is increased by an effective 2.5 years over 40 years, pension benefits reduced on average by almost 25% and social security contributions increased on average by 15%, total social security deficit in 2050 would remain at is 2010 level.

Modest single instrument reforms investigated would not be able to contain the social security deficit. Even a 4 year effective increase phased in over 40 years would lead to an increase in both pension deficit (almost 6% of GDP in 2050) and in social security deficit (above 10% of GDP). A gradual increase of 8 years in effective retirement age would be necessary, essentially matching the increase in life expectancy. From the single instrument reforms, increases in retirement age are the least damaging to economic growth. Among comparable reforms, GDP per capita in 2050 would be reduced to 14.5% with a 1 year increase in retirement age, 17.5% with a 11% pension reduction and almost 19% with a 7% social security contribution increase.

A 2/3 rule of thumb for retirement age increase would be successful in containing pension financing, but not overall social security financing. If the retirement age is increased in a gradual fashion by 2 years for every 3 years of life expectancy gained, pension deficit would be (almost) constant but, once including health insurance, total security deficit would increase from less than 7% to over 10% of GDP. To maintain this deficit constant, a more appropriate rule-of-thumb would be 8/7.

Natives adjust their education decisions to compensate for the relative imbalance in the immigrant skill distribution. As migrants have more low and high skills relative to the natives, natives shift education decisions from high to medium levels, responding to variations in marginal product of labor and wages.

Simulations of the effect of a higher productivity growth illustrate how critical the overall health of the economy is. A 50% higher growth rate would have the same pension deficit reduction effect as an effective increase of 2.5 years of retirement.

6 Conclusion

Taking into account households retirement decisions and age-related health costs is important to measure the impact of population aging and migration on pension and social security financing. It is even more important when evaluating the effect of pension reforms. Previous analyses of migration allow for endogenous labor supply decisions along the intensive margin (hours) but not extensive margins (retirement). This study uses for the first time a general equilibrium overlapping generation model with endogenous labor supply along both margins and age-related health costs to quantify the contribution of migration in social security financing and the effect of pension reforms in Austria.

The two main findings of the numerical simulations are that health expenditures make a significant difference in social security financing when population ages and that migrants, who are younger on average, help but do not solve the challenge of social security financing. Under the main demographic scenario, pension deficit alone would rise to 9.7% of GDP by 2050, while the total social security deficit would rise to 14.7% of GDP. An increase of 25% of migration would reduce the total security deficit to 13.9% of GDP. Another finding is the importance of modeling retirement decisions endogenously, as a constant retirement age overestimates the benefit of migration and bias the evaluation of pension reforms. Section 5.5 contains more on these and other findings.

From a policy perspective, relying on immigration to deal with an aging population and finance retirement is significantly insufficient. Pension reforms are unavoidable and the right balance needs to be found between participation into the future prosperity brought by productivity growth and appetite for leisure.

The analysis carried in this study could be extended in two ways. First, the model used a conservative approach to model the changes in health care costs. We assumed that age-related expenditures were stable over time. Yet, they could change in two dimensions: the concentration of expenditures among the old could further increase, a trend documented in past data but difficult to predict for the future; the share of output dedicated to health services could increase. In the current analysis, we have assumed that health expenditures were stable along these two dimensions.

Second, compared to other European countries, Austria has taken less active immigration measures and with a high proportion of low- and high-skill immigration (Krause and Liebig (2011)). From an Austrian policy design point of view, it could be interesting to extend the analysis to assess the impact of more active immigration policies. For instance, a cost and benefit analysis could be performed for costly education measures to increase the labor market integration of foreigners, reduce the productivity penalty imposed by the labor market and increase the education level of the children of these overrepresented low-skill immigrants.

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A Simulation results details

Table 15: Simulation results of higher productivity growth (2.25% instead of 1.5%) (024)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.17	33.63	41.47	42.38
Effective retirement age	58.79	59.08	59.42	59.35
Unemployment rate	5.90	5.99	6.32	6.62
Employment (yearly hours per worker)	1587	1582	1573	1564
Effective employment (yearly hours per capita)	815	768	668	648
increase from basis in %				
Labor costs	-	-0.59	-1.32	-2.88
Net wages	-	-0.54	-1.06	-2.46
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-5.21	-17.85	-22.07
increase from basis in %				
GDP/capita	-	-4.24	-17.60	-21.56
Capital/capita	-	-6.04	-19.19	-23.38
Consumption/capita	-	-3.95	-22.08	-28.75
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.53	18.04	20.36	19.95
Social security deficit	6.82	8.47	13.99	14.54
Social security deficit (constant population)	6.82	8.09	12.40	12.90
Pension deficit	4.57	5.23	8.30	8.43
Pension deficit (constant population)	4.57	5.00	7.36	7.48
Social security ratio: natives	0.72	0.67	0.53	0.51
Social security ratio: foreigners	0.94	0.93	0.74	0.66

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 16: Simulation results of lower pension benefits (-0.6% of GDP) (150)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.08	33.65	41.73	42.67
Effective retirement age	58.86	59.06	59.24	59.14
Unemployment rate	5.93	6.01	6.35	6.66
Employment (yearly hours per worker)	1587	1582	1573	1564
Effective employment (yearly hours per capita)	815	767	663	643
increase from basis in %				
Labor costs	-	-0.55	-1.34	-2.92
Net wages	-	-0.50	-1.07	-2.48
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-5.10	-11.24	-14.44
increase from basis in %				
GDP/capita	-	-4.67	-17.54	-21.39
Capital/capita	-	-6.13	-19.84	-24.10
Consumption/capita	-	-7.95	-15.96	-20.01
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	16.88	18.06	22.02	21.98
Social security deficit	6.20	8.51	15.67	16.58
Social security deficit (constant population)	6.20	8.13	13.89	14.71
Pension deficit	3.94	5.26	9.98	10.46
Pension deficit (constant population)	3.94	5.03	8.84	9.28
Social security ratio: natives	0.74	0.67	0.50	0.47
Social security ratio: foreigners	0.95	0.92	0.71	0.63

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 17: Simulation results of higher contributions (+1.3% of GDP) (152)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.25	34.09	42.03	42.97
Effective retirement age	58.73	58.76	59.02	58.93
Unemployment rate	6.09	6.19	6.56	6.87
Employment (yearly hours per worker)	1585	1581	1571	1562
Effective employment (yearly hours per capita)	809	757	655	635
increase from basis in %				
Labor costs	-	-0.13	-1.19	-2.75
Net wages	-	-2.61	-3.43	-4.78
Social security contribution	-	6.70	6.70	6.70
Pension payment per beneficiary	-	-1.57	-8.73	-12.23
increase from basis in %				
GDP/capita	-	-5.89	-18.65	-22.46
Capital/capita	-	-7.10	-20.86	-25.05
Consumption/capita	-	-9.02	-17.67	-21.85
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.58	18.99	22.84	22.72
Social security deficit	5.82	8.53	15.67	16.53
Social security deficit (constant population)	5.82	8.15	13.89	14.67
Pension deficit	3.91	5.58	10.25	10.68
Pension deficit (constant population)	3.91	5.33	9.09	9.48
Social security ratio: natives	0.76	0.67	0.51	0.48
Social security ratio: foreigners	0.99	0.95	0.73	0.65

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 18: Simulation results of higher retirement age (+1.4 years) (151)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.71	32.44	40.41	41.41
Effective retirement age	59.14	59.89	60.17	60.05
Unemployment rate	5.97	6.01	6.30	6.61
Employment (yearly hours per worker)	1585	1580	1570	1562
Effective employment (yearly hours per capita)	819	785	683	662
increase from basis in %				
Labor costs	-	-0.67	-0.69	-2.22
Net wages	-	-0.66	-0.49	-1.84
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.36	-6.15	-9.08
increase from basis in %				
GDP/capita	-	-2.13	-14.41	-18.47
Capital/capita	-	-3.87	-16.60	-21.12
Consumption/capita	-	-4.62	-12.77	-17.02
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.23	18.10	22.55	22.67
Social security deficit	6.57	8.20	15.60	16.68
Social security deficit (constant population)	6.57	7.83	13.83	14.81
Pension deficit	4.30	5.06	10.10	10.75
Pension deficit (constant population)	4.30	4.83	8.95	9.54
Social security ratio: natives	0.73	0.68	0.51	0.48
Social security ratio: foreigners	0.94	0.94	0.73	0.65

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 19: Simulation results of lower pension benefits (-0.6% of GDP), of higher contributions (+1.3% of GDP) and higher retirement age (+1.4 years) combined (054)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.69	32.45	40.42	41.41
Effective retirement age	59.16	59.89	60.16	60.05
Unemployment rate	6.19	6.26	6.56	6.88
Employment (yearly hours per worker)	1583	1577	1567	1558
Effective employment (yearly hours per capita)	814	778	677	656
increase from basis in %				
Labor costs	-	-0.22	-0.38	-1.91
Net wages	-	-2.76	-2.72	-4.05
Social security contribution	-	6.70	6.70	6.70
Pension payment per beneficiary	-	-5.18	-10.26	-13.28
increase from basis in %				
GDP/capita	-	-2.82	-15.09	-19.11
Capital/capita	-	-4.38	-17.26	-21.76
Consumption/capita	-	-5.70	-13.39	-17.42
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	16.63	17.40	21.54	21.61
Social security deficit	4.95	6.58	13.75	14.83
Social security deficit (constant population)	4.95	6.28	12.19	13.16
Pension deficit	3.01	3.74	8.52	9.16
Pension deficit (constant population)	3.01	3.57	7.56	8.13
Social security ratio: natives	0.79	0.73	0.55	0.52
Social security ratio: foreigners	1.00	1.00	0.78	0.69

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 20: Simulation results of lower pension benefits (-3% of GDP) (160)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.83	33.01	41.26	42.21
Effective retirement age	59.05	59.50	59.57	59.48
Unemployment rate	6.05	6.14	6.47	6.79
Employment (yearly hours per worker)	1584	1579	1569	1561
Effective employment (yearly hours per capita)	815	772	667	647
increase from basis in %				
Labor costs	-	-0.44	-1.07	-2.70
Net wages	-	-0.43	-0.84	-2.29
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-19.93	-24.71	-27.42
increase from basis in %				
GDP/capita	-	-4.04	-16.90	-20.74
Capital/capita	-	-5.56	-19.37	-23.71
Consumption/capita	-	-8.39	-14.12	-17.45
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	14.36	14.94	18.36	18.38
Social security deficit	3.81	5.44	12.09	13.07
Social security deficit (constant population)	3.81	5.20	10.71	11.60
Pension deficit	1.50	2.16	6.36	6.91
Pension deficit (constant population)	1.50	2.06	5.64	6.14
Social security ratio: natives	0.82	0.75	0.56	0.53
Social security ratio: foreigners	0.99	0.99	0.78	0.70

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 21: Simulation results of higher contributions (+3% of GDP) (008)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.37	34.45	42.28	43.19
Effective retirement age	58.63	58.51	58.85	58.76
Unemployment rate	6.33	6.48	6.88	7.20
Employment (yearly hours per worker)	1583	1578	1567	1559
Effective employment (yearly hours per capita)	801	746	645	626
increase from basis in %				
Labor costs	-	0.46	-0.91	-2.44
Net wages	-	-5.26	-6.35	-7.64
Social security contribution	-	15.46	15.46	15.46
Pension payment per beneficiary	-	-1.76	-9.76	-13.49
increase from basis in %				
GDP/capita	-	-7.25	-19.89	-23.64
Capital/capita	-	-8.18	-22.03	-26.15
Consumption/capita	-	-10.56	-19.28	-23.38
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.66	19.15	22.71	22.51
Social security deficit	4.55	7.59	14.55	15.38
Social security deficit (constant population)	4.55	7.25	12.90	13.65
Pension deficit	3.09	5.00	9.46	9.84
Pension deficit (constant population)	3.09	4.78	8.38	8.73
Social security ratio: natives	0.81	0.71	0.54	0.51
Social security ratio: foreigners	1.05	1.00	0.77	0.69

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 22: Simulation results of higher retirement age (+3 years phased-in over 40 years) (019)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.14	32.94	38.30	39.39
Effective retirement age	58.81	59.55	61.66	61.52
Unemployment rate	5.92	6.03	6.49	6.75
Employment (yearly hours per worker)	1587	1580	1563	1555
Effective employment (yearly hours per capita)	814	776	708	686
increase from basis in %				
Labor costs	-	-0.45	-0.94	-2.00
Net wages	-	-0.44	-0.83	-1.71
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.33	-5.05	-6.11
increase from basis in %				
GDP/capita	-	-3.30	-11.53	-15.35
Capital/capita	-	-5.05	-14.52	-18.48
Consumption/capita	-	-4.94	-10.80	-14.12
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.52	18.39	21.59	22.25
Social security deficit	6.81	8.60	14.14	15.67
Social security deficit (constant population)	6.81	8.22	12.54	13.91
Pension deficit	4.56	5.43	8.79	9.92
Pension deficit (constant population)	4.56	5.18	7.79	8.80
Social security ratio: natives	0.72	0.67	0.54	0.50
Social security ratio: foreigners	0.94	0.93	0.76	0.67

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 23: Simulation results of lower pension benefits (-3% of GDP), of higher contributions (+3% of GDP) and higher retirement age (+3 years phased-in over 40 years) combined (055)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.92	32.41	37.75	38.79
Effective retirement age	58.98	59.92	62.05	61.95
Unemployment rate	6.51	6.71	7.18	7.45
Employment (yearly hours per worker)	1579	1570	1552	1543
Effective employment (yearly hours per capita)	802	767	699	678
increase from basis in %				
Labor costs	-	0.66	0.04	-1.05
Net wages	-	-5.16	-5.65	-6.52
Social security contribution	-	15.46	15.46	15.46
Pension payment per beneficiary	-	-20.10	-23.62	-24.76
increase from basis in %				
GDP/capita	-	-4.25	-12.21	-15.88
Capital/capita	-	-5.69	-15.34	-19.27
Consumption/capita	-	-7.41	-10.54	-12.86
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	14.40	14.63	16.98	17.48
Social security deficit	1.48	2.79	7.55	9.01
Social security deficit (constant population)	1.48	2.66	6.70	8.00
Pension deficit	-0.06	0.27	2.83	3.86
Pension deficit (constant population)	-0.06	0.26	2.51	3.43
Social security ratio: natives	0.92	0.86	0.69	0.65
Social security ratio: foreigners	1.11	1.12	0.95	0.84

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 24: Simulation results of lower pension benefits (-5% of GDP) (011)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.69	32.61	40.94	41.89
Effective retirement age	59.16	59.78	59.80	59.71
Unemployment rate	6.13	6.25	6.58	6.90
Employment (yearly hours per worker)	1582	1576	1567	1558
Effective employment (yearly hours per capita)	814	775	668	648
increase from basis in %				
Labor costs	-	-0.34	-0.89	-2.54
Net wages	-	-0.35	-0.67	-2.14
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-32.35	-36.18	-38.47
increase from basis in %				
GDP/capita	-	-3.74	-16.54	-20.35
Capital/capita	-	-5.27	-19.13	-23.53
Consumption/capita	-	-9.01	-12.81	-15.52
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	12.33	12.45	15.33	15.41
Social security deficit	1.88	3.02	9.16	10.20
Social security deficit (constant population)	1.88	2.88	8.12	9.05
Pension deficit	-0.48	-0.29	3.39	4.00
Pension deficit (constant population)	-0.48	-0.28	3.01	3.55
Social security ratio: natives	0.90	0.84	0.62	0.58
Social security ratio: foreigners	1.03	1.06	0.85	0.76

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 25: Simulation results of higher retirement age (+5 years phased-in over 40 years) (203)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.13	32.36	35.87	36.94
Effective retirement age	58.82	59.95	63.39	63.29
Unemployment rate	5.94	6.09	6.62	6.85
Employment (yearly hours per worker)	1586	1578	1554	1546
Effective employment (yearly hours per capita)	814	783	737	715
increase from basis in %				
Labor costs	-	-0.34	-0.37	-0.99
Net wages	-	-0.35	-0.36	-0.81
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.56	-6.20	-7.15
increase from basis in %				
GDP/capita	-	-2.35	-7.31	-10.79
Capital/capita	-	-4.28	-10.73	-14.24
Consumption/capita	-	-3.13	-7.00	-9.33
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.52	18.02	19.95	20.63
Social security deficit	6.81	8.10	11.79	13.26
Social security deficit (constant population)	6.81	7.74	10.45	11.77
Pension deficit	4.55	4.96	6.64	7.75
Pension deficit (constant population)	4.55	4.74	5.89	6.87
Social security ratio: natives	0.72	0.68	0.59	0.55
Social security ratio: foreigners	0.94	0.94	0.82	0.73

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 26: Simulation results of higher retirement age (+9 years phased-in over 40 years) (207)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.11	31.22	31.21	31.73
Effective retirement age	58.83	60.74	66.68	67.05
Unemployment rate	5.97	6.17	6.76	6.87
Employment (yearly hours per worker)	1585	1573	1528	1521
Effective employment (yearly hours per capita)	813	795	787	776
increase from basis in %				
Labor costs	-	-0.17	2.01	4.65
Net wages	-	-0.23	1.82	4.55
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.71	-6.03	-4.72
increase from basis in %				
GDP/capita	-	-0.38	1.63	2.04
Capital/capita	-	-2.72	-2.56	-1.48
Consumption/capita	-	1.05	1.87	4.10
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.50	17.36	17.31	18.14
Social security deficit	6.80	7.16	7.65	8.42
Social security deficit (constant population)	6.80	6.84	6.78	7.47
Pension deficit	4.54	4.10	2.95	3.63
Pension deficit (constant population)	4.54	3.92	2.62	3.22
Social security ratio: natives	0.72	0.71	0.69	0.67
Social security ratio: foreigners	0.94	0.97	0.96	0.87

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 27: Simulation results of pensions inflation indexation (003)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.16	33.81	41.73	42.65
Effective retirement age	58.80	58.95	59.24	59.16
Unemployment rate	5.93	6.01	6.36	6.67
Employment (yearly hours per worker)	1587	1582	1572	1564
Effective employment (yearly hours per capita)	814	765	663	644
increase from basis in %				
Labor costs	-	-0.50	-1.34	-2.90
Net wages	-	-0.44	-1.07	-2.46
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.84	-10.28	-14.13
increase from basis in %				
GDP/capita	-	-4.96	-17.63	-21.40
Capital/capita	-	-6.35	-19.86	-24.07
Consumption/capita	-	-8.14	-16.32	-20.26
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.53	18.78	22.31	22.08
Social security deficit	6.82	9.24	15.95	16.67
Social security deficit (constant population)	6.82	8.83	14.14	14.79
Pension deficit	4.57	5.99	10.26	10.56
Pension deficit (constant population)	4.57	5.72	9.10	9.37
Social security ratio: natives	0.72	0.65	0.49	0.47
Social security ratio: foreigners	0.94	0.91	0.70	0.63

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 28: Simulation results of higher penalty in the pension corridor (5.2% instead of 2.1%) (007)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	28.61	32.27	40.52	41.48
Effective retirement age	59.22	60.02	60.09	60.00
Unemployment rate	6.00	6.08	6.37	6.69
Employment (yearly hours per worker)	1585	1579	1570	1562
Effective employment (yearly hours per capita)	820	785	680	659
increase from basis in %				
Labor costs	-	-0.74	-1.00	-2.63
Net wages	-	-0.75	-0.80	-2.25
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.99	-7.85	-11.08
increase from basis in %				
GDP/capita	-	-2.28	-15.19	-19.14
Capital/capita	-	-4.31	-17.61	-22.00
Consumption/capita	-	-4.93	-13.33	-17.60
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.18	17.89	22.22	22.22
Social security deficit	6.49	7.99	15.41	16.39
Social security deficit (constant population)	6.49	7.64	13.66	14.54
Pension deficit	4.22	4.85	9.86	10.41
Pension deficit (constant population)	4.22	4.63	8.74	9.23
Social security ratio: natives	0.73	0.68	0.51	0.48
Social security ratio: foreigners	0.94	0.94	0.72	0.64

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 29: Simulation results of higher reference year for the pension corridor (65.5 instead of 62.5) (013)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.18	33.80	41.79	42.73
Effective retirement age	58.78	58.96	59.20	59.10
Unemployment rate	5.91	5.99	6.34	6.65
Employment (yearly hours per worker)	1587	1583	1573	1565
Effective employment (yearly hours per capita)	814	766	663	643
increase from basis in %				
Labor costs	-	-0.54	-1.37	-2.94
Net wages	-	-0.48	-1.10	-2.49
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-2.62	-10.42	-13.84
increase from basis in %				
GDP/capita	-	-4.90	-17.68	-21.50
Capital/capita	-	-6.31	-19.91	-24.15
Consumption/capita	-	-8.02	-16.38	-20.47
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.53	18.63	22.30	22.19
Social security deficit	6.81	9.09	15.95	16.79
Social security deficit (constant population)	6.81	8.68	14.14	14.90
Pension deficit	4.56	5.84	10.26	10.68
Pension deficit (constant population)	4.56	5.58	9.10	9.47
Social security ratio: natives	0.72	0.65	0.49	0.47
Social security ratio: foreigners	0.94	0.92	0.70	0.63

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 30: Simulation results of the high migration scenario with budget closing SSC (045)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	105.69	118.78	121.94
Share of foreigners	10.73	14.75	27.22	34.21
Dependency ratio	26.66	33.01	48.64	50.86
Pensioners (in % of population)	29.20	34.44	43.58	43.65
Effective retirement age	58.76	58.32	57.22	57.75
Unemployment rate	5.96	6.77	9.60	9.64
Employment (yearly hours per worker)	1589	1577	1541	1530
Effective employment (yearly hours per capita)	814	739	575	570
increase from basis in %				
Labor costs	-	0.00	0.96	0.08
Net wages	-	-7.17	-24.86	-24.34
Social security contribution	-	24.42	94.13	89.84
Pension payment per beneficiary	-	-1.43	-13.20	-20.33
increase from basis in %				
GDP/capita	-	-8.70	-29.24	-30.47
Capital/capita	-	-9.68	-31.18	-32.46
Consumption/capita	-	-13.70	-26.57	-28.97
in % of basis GDP				
Health expenditure	7.96	8.92	11.40	11.89
Pension expenditure	17.56	19.39	23.69	22.62
Social security deficit	6.79	6.79	6.79	6.79
Social security deficit (constant population)	6.79	6.42	5.72	5.57
Pension deficit	4.55	4.50	4.26	3.56
Pension deficit (constant population)	4.55	4.26	3.59	2.92
Social security ratio: natives	0.72	0.73	0.74	0.75
Social security ratio: foreigners	0.94	1.06	1.10	0.98

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 31: Simulation results of the main scenario with non-age dependent health costs (301)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.16	33.85	41.86	42.81
Effective retirement age	58.80	58.93	59.14	59.04
Unemployment rate	5.90	5.98	6.32	6.63
Employment (yearly hours per worker)	1587	1583	1573	1565
Effective employment (yearly hours per capita)	815	766	662	642
increase from basis in %				
Labor costs	-	-0.57	-1.41	-2.98
Net wages	-	-0.51	-1.14	-2.53
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.42	-7.94	-11.26
increase from basis in %				
GDP/capita	-	-4.78	-17.52	-21.32
Capital/capita	-	-6.33	-20.00	-24.25
Consumption/capita	-	-6.41	-13.90	-17.52
in % of basis GDP				
Health expenditure	7.96	8.28	8.84	8.81
Pension expenditure	17.53	18.88	22.94	22.89
Social security deficit	6.82	8.72	14.44	15.15
Social security deficit (constant population)	6.82	8.33	12.80	13.44
Pension deficit	4.57	6.08	10.89	11.36
Pension deficit (constant population)	4.57	5.81	9.66	10.08
Social security ratio: natives	0.73	0.67	0.52	0.49
Social security ratio: foreigners	0.86	0.87	0.72	0.65

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 32: Simulation results of the main scenario with exogenous retirement decisions (350)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.11	33.99	42.36	43.19
Effective retirement age	58.83	58.83	58.79	58.77
Unemployment rate	5.91	5.96	6.32	6.64
Employment (yearly hours per worker)	1587	1583	1574	1566
Effective employment (yearly hours per capita)	816	764	656	637
increase from basis in %				
Labor costs	-	-0.63	-1.61	-3.21
Net wages	-	-0.56	-1.29	-2.73
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.38	-8.43	-11.94
increase from basis in %				
GDP/capita	-	-5.15	-18.77	-22.48
Capital/capita	-	-6.50	-21.00	-25.17
Consumption/capita	-	-8.41	-17.45	-21.70
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	17.50	18.97	23.10	22.91
Social security deficit	6.79	9.46	16.91	17.65
Social security deficit (constant population)	6.79	9.03	14.99	15.67
Pension deficit	4.54	6.20	11.17	11.50
Pension deficit (constant population)	4.54	5.92	9.91	10.20
Social security ratio: natives	0.72	0.64	0.48	0.45
Social security ratio: foreigners	0.94	0.91	0.69	0.62

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 33: Simulation results of the high migration scenario with exogenous retirement decisions (351)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	105.69	118.78	121.94
Share of foreigners	10.73	14.75	27.22	34.21
Dependency ratio	26.66	33.01	48.64	50.86
Pensioners (in % of population)	29.11	33.71	41.39	42.26
Effective retirement age	58.83	58.83	58.79	58.76
Unemployment rate	5.91	5.99	6.42	6.59
Employment (yearly hours per worker)	1587	1583	1571	1563
Effective employment (yearly hours per capita)	816	766	662	645
increase from basis in %				
Labor costs	-	-0.88	-2.37	-2.48
Net wages	-	-0.78	-1.95	-1.91
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-1.42	-9.27	-13.15
increase from basis in %				
GDP/capita	-	-5.05	-18.44	-21.30
Capital/capita	-	-6.53	-20.86	-23.43
Consumption/capita	-	-7.50	-16.51	-19.04
in % of basis GDP				
Health expenditure	7.96	8.92	11.40	11.89
Pension expenditure	17.50	18.98	23.50	23.86
Social security deficit	6.79	9.34	16.83	17.71
Social security deficit (constant population)	6.79	8.84	14.17	14.52
Pension deficit	4.54	6.09	10.93	11.30
Pension deficit (constant population)	4.54	5.76	9.20	9.27
Social security ratio: natives	0.72	0.64	0.48	0.47
Social security ratio: foreigners	0.94	0.94	0.73	0.64

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 34: Simulation results of lower pension benefits (-3% GDP) with exogenous retirement decisions (352)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.11	33.99	42.36	43.19
Effective retirement age	58.83	58.83	58.79	58.77
Unemployment rate	6.00	6.09	6.46	6.79
Employment (yearly hours per worker)	1585	1581	1571	1563
Effective employment (yearly hours per capita)	812	760	652	633
increase from basis in %				
Labor costs	-	-0.40	-1.47	-3.09
Net wages	-	-0.33	-1.15	-2.61
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-20.11	-25.89	-28.78
increase from basis in %				
GDP/capita	-	-5.73	-19.15	-22.79
Capital/capita	-	-6.85	-21.50	-25.69
Consumption/capita	-	-10.54	-16.62	-19.86
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	14.50	15.35	18.57	18.47
Social security deficit	3.95	6.09	12.71	13.52
Social security deficit (constant population)	3.95	5.82	11.26	12.00
Pension deficit	1.64	2.74	6.85	7.25
Pension deficit (constant population)	1.64	2.62	6.08	6.44
Social security ratio: natives	0.81	0.73	0.54	0.51
Social security ratio: foreigners	0.99	0.98	0.77	0.69

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

Table 35: Simulation results of lower pension benefits (-0.65% GDP) with exogenous retirement decisions (355)

	2011	2020	2050	2070
absolute numbers				
Population (15+)	100.00	104.69	112.80	112.69
Share of foreigners	10.73	14.09	24.42	30.79
Dependency ratio	26.66	33.39	50.58	52.83
Pensioners (in % of population)	29.11	33.99	42.36	43.19
Effective retirement age	58.83	58.83	58.79	58.77
Unemployment rate	5.93	5.99	6.35	6.68
Employment (yearly hours per worker)	1587	1583	1574	1565
Effective employment (yearly hours per capita)	815	763	655	636
increase from basis in %				
Labor costs	-	-0.58	-1.58	-3.18
Net wages	-	-0.51	-1.26	-2.70
Social security contribution	-	0.00	0.00	0.00
Pension payment per beneficiary	-	-5.44	-12.22	-15.59
increase from basis in %				
GDP/capita	-	-5.27	-18.85	-22.55
Capital/capita	-	-6.58	-21.10	-25.28
Consumption/capita	-	-8.87	-17.27	-21.30
in % of basis GDP				
Health expenditure	7.96	8.88	10.97	11.13
Pension expenditure	16.85	18.19	22.12	21.95
Social security deficit	6.18	8.73	16.00	16.76
Social security deficit (constant population)	6.18	8.34	14.18	14.87
Pension deficit	3.91	5.45	10.24	10.58
Pension deficit (constant population)	3.91	5.21	9.08	9.39
Social security ratio: natives	0.74	0.66	0.49	0.47
Social security ratio: foreigners	0.95	0.92	0.71	0.63

Notes: Social security ratio gives the ratio of total social security revenues over expenditure.

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