Fiscal Impact of High-Skilled Immigration in Germany: An OLG Model

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February 28, 2022

Abstract

In this paper we analyze the fiscal impact of different immigration policies utilizing an overlapping generational model calibrated to the German economy. Our model has two types of agents: native and high-skilled immigrants. We investigate the fiscal impact of three different arrival ages - 25, 40, 55 - of the high-skilled immigrants. Our findings show that immigrants arriving at ages 25 and 40 have positive fiscal effects, while immigrants arriving at age 55 have a negative effect on the deficit (budget balance). Our analysis shows that with the right immigration policies Germany could alleviate some of the fiscal burden borne by an aging population.

1 Introduction

Population aging, with the combined effects of lower birth rates and longer life expectancy, has been a challenge for many developed countries. Besides its impact on public spending, population aging has imposed a negative effect on the labor market, as well (Federal Ministry of Finance, 2021). One particular case is Germany, where the median age has been rising for over a decade, reaching the age of 40.1 in 2020 (United Nations, 2019). Being already an "old" country, the UN forecasts median age to rise even further to 49 till 2045 (United Nations, 2019). In parallel, from the labor market side, the working-age population (ages 20–66), is expected to decline by approximately 6 million by 2040 and by approximately 9 million till 2060 (Federal Ministry of Finance, 2021). Accordingly, the number of workers per retiree is expected to decline from 2.5 to 1.7 in 2045 (OECD, 2022a). These indicators already give hints about fiscal consequences; with a potential decline in the labor force and higher outflows to the elderly, ceteris paribus, the federal government budget is expected to be hurt. As a matter of fact, the German Federal Ministry of Finances estimates age-related government spending to increase disproportionately to GDP and considers population aging as a major challenge to the sustainability of public finances (Federal Ministry of Finance, 2021). Particularly, Germany faces a skilled labor shortage. Around 1.2 million unfilled job vacancies in the country in 2020 are forecasted to increase even further, with 3.9 million fewer workers in 2030 than today (Federal Ministry of Finance, 2021). In order to deal with this issue, the country adopted the Skilled Immigration Act in 2020, which aims to satisfy the needs of the labor market with qualified people; the act makes entry and residence easier for skilled immigrants from non-EU countries (Federal Ministry of Finance, 2021). Hence, this paper explores the fiscal impact of skilled immigration inflow in Germany. Particularly, the paper focuses on by how much an inflow of skilled immigration-at the ages of 25, 40 and 55- will have an impact on the government budget in Germany. The question to be answered is closely related to the one addressed by Kjetil Storesletten (2000) for the U.S., "Sustaining fiscal policy through immigration", although our model is a simplified version of it. Particularly, compared to his model, we do not consider illegal immigration, return migration process, family immigration and longevity uncertainty.

More specifically, we use a large-scale overlapping generations (OLG) model, where one model period is equal to one year. Three experiments are conducted and these experiments are different only with respect to the arrival age of the immigrants. That means, in each experiment we look at the impact of high-skilled immigrants on the government budget at one specific age, either 25, 40 or 55. In this way, we are able to figure out how the fiscal impact of immigration inflow changes with respect to different arrival ages. In each experiment, the quantitative impact of immigration inflow is derived through a comparison of an initial steady state, which assumes no immigration and a final steady state with skilled immigrants. The model is calibrated to represent the German economy. The paper's main finding is that inflows of high-skilled immigrants at age 25 and 40 generate a government surplus, but immigration at age 55 generates a budget deficit. This points to there being an optimal age for high skilled immigration policies, or, more specifically, that there is an upper limit to where high-skilled immigration is good for the government budget. However, we also find that high-skilled immigration brings with it high inequality as the gini-index for disposable income rises when immigration is introduced.

Related Literature

There is an abundance of literature investigating the effects of immigration on fiscal policy and welfare. Kjetil Storesletten (2000) questions if immigration policy could lead to a fiscal balance in the United States if no other fiscal reforms are conducted. His paper uses a calibrated general equilibrium OLG model. Utilising this model he investigates the effects of both legal and illegal immigration while allowing immigrants to have three different skill types - low, medium, and high - and assumes natives are homogenous in their skill level. Storesletten finds that the optimal immigration policy is to target high-skilled 40-44 year olds and that immigration by roughly 1.6 million of these high-skilled immigrants could balance the US budget. S. N. Akin (2012) focuses on the welfare effects of immigration in Germany by utilising an OLG model with heterogeneous agents differing in skill, age and immigration status. Akin finds that annual immigration of 0.4 percent of the population would increase welfare and consumption. Furthermore, Akin finds that the net effect of immigration on pensions is positive and the positive effects on welfare from immigration holds regardless of the skill level. Auerbrach and Oreopoulos (1999) analyse the fiscal effects of immigration on the U.S. They find that the impact of immigration on the fiscal balance is relatively small and that immigration is neither a source of fiscal imbalance nor a solution to it. D'Albis et al. (2019) investigated the effects of immigration on public finances in 19 OECD countries. They use a structural vector autoregression model to estimate the effects. Utilising this model they find immigration leads to an increase in GDP per capita. Contrary to Auerbrach & Oreopoulos, d'Albis et al. find that immigration increases fiscal balance. Chassambouli & Peri (2020) evaluate the economic effects of immigration policies in the US, taking into account three main types of immigration: employment-based, family-based, and illegal. Overall they find that all three types of immigration, with skill levels varying between high and low, have positive effects on job creation. Iftikhar and Zaharieva (2019) use a search and matching model calibrated to the German labour market to investigate the impact of immigration. They allow for only two skill groups with two production sectors, manufacturing and services. Iftikhar and Zaharieva find that immigration has a net positive effect on welfare for workers. Another paper looking at the effects of immigration on Germany is by Maffei-Faccioli and Vella (2021). They utilise a structural vector autoregression model to analyse the effects. They find immigration leads to a decline in total unemployment and has other positive economic effects. Furlanetto and Robstad (2019) also use a vector autoregression model to investigate the effects of immigration in Norway. Their findings are in line with Maffei-Faccioli and Vella, immigration lowers unemployment. Furthermore, they find that immigration has a positive effect on prices and public finance. Guerrerio et al. (2020) investigate the welfare effects of immigration. They find it is optimal to target high-skilled immigrants and it is possible to utilise the tax code to discourage low-skilled immigration.

2 Model Environment

This section develops an OLG model with 61 periods, from the real age 25 to age 85. Details of this framework are analyzed in the following.

2.1 Demographics and Endowments

Each period a continuum of agents is born. They enter the model at age 25, which corresponds to model age 1 and remain in the model until they die at the age 85. The type of an agent is denoted by (j, s) where j denotes age and s denotes legal status; $s \in \{0,1\}$ takes value 0 for natives and 1 for immigrants. The relative size of each cohort j of native people, $\psi_{j,0}$ and immigrants, $\psi_{j,1}$ is determined by:

$$\psi_{j+1,0} = \frac{\psi_{j,0}}{1+n}, \text{ for } j = 1,...,J-1$$

with some arbitary $\psi_{1,0} = \bar{\psi} > 0$ and constant population growth n.

$$\psi_{j+1,1} = \frac{\psi_{j,1}}{1+n}, \text{ for } j = A,...,J-1$$

with $\psi_{A,1}= \lambda\, \psi_{A,0}$.

A is a set containing the arrival age of immigrants and λ is the size of immigration inflow as a proportion of the respective native cohort. Age distribution of both natives and immigrants are normalized by sum of total age distribution $\psi_j= \psi_{j,0}+\psi_{j,1}$, so total population size is equal to 1. If $\lambda = 0$, then we are in the initial steady state and $\psi_j = \psi_{j,0}$. As seen from the formulas, it is assumed that population growth of immigrants is the same as that of the native population. Both natives and immigrants have no initial capital when they enter the labor market (i.e. for $j = 1$ $k_{j,0}$=0 and $k_{A,1}$= 0), but they can save and rent to firms at interest rate r, which is subject to capital tax, τ_k. It is assumed that there is no bequest motive (i.e. $k_{j+1,s}$= 0 for $j = J$) and there is no borrowing (i.e. $k_{j,s} \geq 0$ for all $j = 1,...J$). A worker of age j , type s supplies labor $l_{j,s}$ and pays proportional labor τ_l and pension tax τ_p . Accordingly, they receive after-tax labor income $(1-\tau_l-\tau_p)wl_{j,s}e_{j,s}$, where w is the wage rate and $e_{j,s}$ is the productivity per hour. It is important to mention that native and immigrant labor are assumed to be perfect substitutes. While the wage rate is the same across all types, it is the productivity that is the key difference between immigrants and natives. Productivity of both natives and immigrants are dependent on age, but on top of that immigrants are high skilled:

$$e_{j,s} = \begin{cases} e_j, & \text{if } s = 0 \\ e_j^H, & \text{otherwise} \end{cases}$$

Agents retire at age J^R, after which their productivity becomes zero and they receive fixed pension benefits, b_j:

$$b_j = \begin{cases} 0, & \text{if } j < J^R \\ b, & \text{otherwise} \end{cases}$$

Additionally, households receive fixed lump-sum transfers t; note that lump-sum transfer, t is not indexed by age and type, since it is the same across all types.
The instantaneous utility function of the agent is given by:

$$u(c_{j,s},\ell_{j,s}) = \frac{\left(c_{j,s}^{\gamma}(1-\ell_{j,s})^{1-\gamma}\right)^{1-\sigma} - 1}{1-\sigma} \tag{1}$$

with $c_{j,s}$ denoting consumption and $\ell_{j,s}$ denoting labor supply at age j for type s. The weight on consumption is γ and the coefficient of relative risk aversion is σ. The household's optimization problem is given by

$$max \sum_{j=max\{1,A\}}^{J} \beta^{j-1} u(c_{j,s},\ell_{j,s})$$

subject to

$$c_{j,s} + k_{j+1,s} = (1-\tau_l-\tau_p)we_{j,s}l_{j,s} + [1+(1-\tau_k)r]\,k_{j,s} + t + b_j$$

Basically, being bounded by the budget constraint, households choose optimal saving, consumption and labor through maximizing their lifetime utility, with discount factor β. We solve this problem using a dynammic programming approach. Let the indirect utility function of an agent, who holds asset k, be:

$$V_{j,s}(k) = max\{u(c_s,l_s)+\beta V_{j+1,s}(k')\},$$

where a prime denotes tomorrow's variables. If we replace consumption, c_s, in the utility function using the budget constraint, the value function exactly pins down the above shown optimization problem.

In order to solve the problem, we use backward induction, so we begin with the value function at period J . Here we use two model assumptions that no labor is supplied after retirement and there is no bequest motive:

$$V_{J,s}(k) = u(c_s,l_s),$$

with $c_s = [1+(1-\tau_k)r]k_s+t+b_J$ and $l = 0$

Assuming that we know $V_{J,s}$ we proceed backward to the period $J-1$, where the value function is:

$$V_{J-1,s}(k) = max_{\{(k_s')\}}\{u(c_s,l_s)+\beta V_J(k_s')\},$$

with $c_s = [1+(1-\tau_k)r]k_s+t+b_{J-1}-k_s'$ and $l_s = 0$

As we go backward, we reach the working age period $j < J^R$:

$$V_{j,s}(k_s) = max_{\{(k'_s)\}}\{u(c_s, l_s) + \beta V_{j+1,s}(k'_s)\},$$
$$\text{with } c_s = (1-\tau_l-\tau_p)we_{j,s}l_s + [1+(1-\tau_k)r]k_s + t - k' \text{ and } l_s = l^*_s(k_j, k_{j+1})\ ^1$$

Once we reach period 1, becuase the initial capital is known (i.e. by assumption $k_{1,0}$=0 or $k_{A,1}$= 0), we can evenutally recover optimal saving decisions, and accordingly consumption and labor choices of households.

2.2 Firms

There is a continuum of identical firms producing output good with constant return to scale production technology $Y = K^{\alpha}L^{(1-\alpha)}$, where α denotes capital share, Y is aggregate output, K is aggregate capital stock and L is aggregate labor. Capital depreciates at rate δ. The labor and capital markets are perfectly competitive, so firms behave according to:

$$F_k(K,L) = r + \delta \tag{2}$$

$$F_l(K,L) = w \tag{3}$$

2.3 Government

There is a government who collects a pension tax from people and redistributes it equally as a pension benefits among retirees with a balanced pension budget:

$$\tau_p wL = b \sum_{j=J^R}^{J} \psi_j \tag{4}$$

and provides age-specific lump-sum transfers financed by labor tax and capital tax, with the possibility of running budget deficit:

$$\tau_l wL + \tau_k rK = D + \sum_{j=1}^{J} \psi_j t \tag{5}$$

2.4 Equilibrium

Initial Steady State

In the initial steady state, we set government deficit, D, to zero. Then, given initial conditions for capital, age distribution, deficit level and taxes, steady state equilibrium in the economy is an allocatoon $\{c_{j,s}, k_{j+1,s}, l_{j,s}\}_{j=1}^{J}$, prices (w,r), aggregate variables (K,L), policy variables (t, b_j) and age distribituion ψ_j such that:

[1] for the full formula of l^*, see appendix section 6.1

- Given $(t_l, t_k, t_p, w, r, t, b_j)$ households choose $\{c_{j,s}, k_{j+1,s}, l_{j,s}\}_{j=1}^{J}$
- Given (w, r) firms behave according to (2) and (3)
- Labor market clears: $\sum_{j=1}^{J^R-1}(\psi_{j,0} l_{j,0} e_{j,0} + \psi_{j,1} l_{j,1} e_{j,1}) = L$
- Capital market clears: $\sum_{j=1}^{J}(\psi_{j,0} k_{j+1} + \psi_{j,1} k_{j+1}) = K$
- Goods market clears: $\sum_{j=1}^{J}(\psi_{j,0} c_{j,0} + \psi_{j,1} c_{j,1}) + \delta K = F(K, L)$
- Pension benefit, b balanced government budget (4) and transfer payments, t balances the budget (5)

Experiment

As seen, in the initial steady state, pension benefits and transfer payments are found endogeneously. Then, the endogeneously found transfer payments from the initial steady state is taken as a given value to find the final steady state with immigration. Here, the government deficit D (along with the pension benefit b) is found endogeneously. All other equibilirium conditions stay the same.

3 Calibration

Overview

The model is calibrated to the German economy. One period of the model equals one year. A model agent correlates to a household in the data. The calibration strategy for each model parameter took one of three forms: exogenous calibration based on data, inside the model calibration, and parameterization. The primary data used for exogenous calibration is the Household Finance and Consumption Survey (HFCS). All moments computed using this data set are from Germany for 2017 as this is the last available wave of the data. A complete table of all parameter values can be found in appendix section 6.2. In the following, we discuss the calibration strategy for each parameter in detail. Finally, we discuss the model fit by showing how non-targeted data moments compare to the data.

Demographics

Each agent's life span J is 61 years. This corresponds to ages 25 to 85 inclusive which is the range of ages where data is best available. We assume that agent's lives begin at age 25 and that they immediately begin working. The retirement age J^R is set to 43 which corresponds to age 66. The retirement age 66 corresponds to the current average retirement age in Germany (OECD, 2021a).

The population growth rate n is calibrated exogenously to 0.0068 or 0.68% from the HFCS using data on the working age population. This is done by taking the average difference in population size between each age cohort. We take only the working age population into consideration since we assume a constant population growth rate in our model and want to avoid including confounding death rates that may be more prevalent in growth rates where retired agents are included.[2] This growth rate is also consistent with OECD estimates for the same time period as our data as it lies between the OECD estimate for 2016 of 0.8% and 0.4% of 2017 (OECD, 2022b). For simplicity, the population growth rate is assumed to be the same for both native and immigrant households.

Immigration

As discussed in the model environment, immigration is assumed to occur once at a fixed proportion to the current native population at the specified age. In our baseline experiments, this proportion λ is set to 0.3 or 30% of the native population. 30% of the respective native age cohort in Germany represents, on average, around 400,000 immigrants[3]. The age at which the immigrant cohort enters the country A varies for each of our three main experiments. In the model, A is set to 1, 16 or 31 correlating to immigrants entering the country at age 25, age 40, or age 55. We chose these specific ages as they represent even intervals of immigrants entering the country at unique stages of their working life: either at the beginning, in the middle, or at the end.

Utility and Technology

We assume the lifetime utility function of each household to be represented by the function in (1). The choice of this utility function is consistent with other literature on this subject, such as Storesletten (2000).

The relative weight on consumption γ is calibrated inside the model to match an average labor supply of 38% (HFCS). Similarly, the discount factor β is calibrated endogenously to match the german capital to output ratio of 3.6 (Busch et al., 2020). The endogenous calibration was done by way of minimizing the sum of squared errors of the targeted model moments given a series of ten plausible parameter values relative to the true moments from the data. Plots of the sum of squared deviations for both parameters showed concavity and thus that unique minimums exist. These plots can be found in appendix section 6.3.

The degree of relative risk aversion $\sigma$is parameterized to 2 from Akin (2012), a value which matches literature generally on the this topic. The share of capital α and the depreciation rate δ are both borrowed form Busch et al. (2020) and set to 0.33 and 0.05 respectively.

Labor Productivity

The central source of heterogeneity in the model comes form variation in productivity across age and legal status. Since it would be very difficult to capture productivity directly form the data, we use wages earned at each stage of life as a proxy for labor productivity. The labor productivity for both natives and immigrants are calibrated from the HFCS. The sample is restricted to working age

[2]However, it should be noted that the population growth rate calibrated when all ages from the data (17-85) are included does not change.

[3]We chose 400,000 because this corresponds to the number of high-skilled immigrants the Federal Labor Agency Charimen Detlef Scheele estimated were needed (Deutsche Welle, 2021).

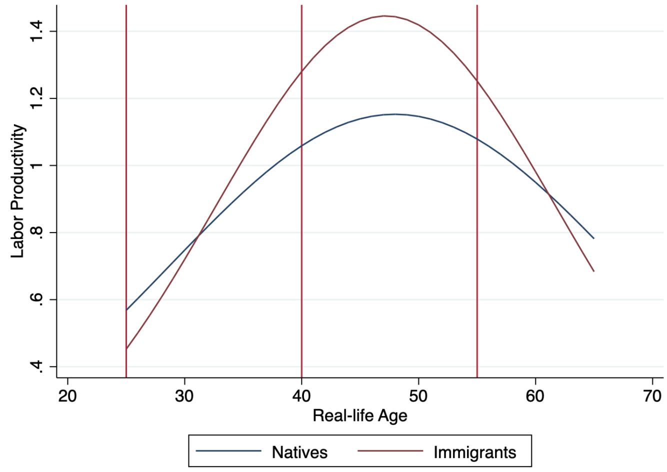

Figure 1: Calibrated Age-Efficiency Profiles for Natives and High-Skilled Immigrants

individuals who worked more than 260 hours annually. We take the attainment of tertiary education to indicate high-skill.

We assume that native and immigrant labor are perfect substitutes and that high-skilled immigrants have the same labor productivity as high-skilled natives. This assumption is made for simplicity, however, it should be noted that it may be an overestimation due to the immigrant wage gap. In appendix section 6.4 we show, however, that our results hold when the immigrant wage gap is taken into account. Additionally, we note that in the long-run the wage gap disappears and thus that, in the long-run, our assumption is justified. Natives' labor productivity represents an average productivity across all levels of education.

The age efficiency profile $\{e_{j,s}\}$ is calibrated as follows. First, we compute the hourly wages for each observation by dividing annual earnings by annual hours worked. Next, we calculate the average hourly wage by age and education and normalize them by the average hourly wage computed for the whole sample. Finally, we fit a quadratic polynomial to each profile to smooth out the approximation.

Figure 1 shows the resulting age-efficiency profiles for both natives and high-skilled immigrants. Vertical lines indicate the three separate ages at which cohorts of high-skilled immigrants enter the country for each experiment. It shows that high-skilled immigrants are more efficient in the middle of their lives, but that they earn less at the very beginning and end of their lives. This might be due to additional schooling having to be completed before beginning a career and that some high-skilled jobs become too difficult at the end of working age (i.e. a tech job where new people trained in new technologies are required). Specifically, at the peak of the age-efficiency profiles, high-skilled immigrants are roughly 20% more efficient than native. One can see that high-skilled immigrants arriving at age 40 do not spend the early, not-as-efficient years of their lives outside of the country and only enter close to their most efficient age of about 47. Immigrants that enter the country at age 55, on the other hand, also spend their most efficient years abroad and only enter the country after their efficiency has already declined. Immigrants entering at age 25 spend their entire efficiency trajectory in the country.

Government

The capital income tax rate τ_k is set to 0.25 or 25% which matches the current capital income tax rate in Germany (Busch et al., 2020). Similarly, the social security tax rate τ_p is set to 0.093 or 9.3% which corresponds to Germany's current employee social security contributions (PWC, 2020). The labor tax rate τ_l is set to 0.296 or 29.6%. This is taken from OECD estimates of the net average tax rate for 2020 minus the social security tax rate (as this is captured separately in our model) (OECD, 2021b).

Model Fit

Since most parameters in the model were directly targeted, to evaluate the model fit we focus on the population growth rate. This is particularly useful for our analysis since the population growth rate is what builds our age distribution which is the mechanism through which immigration is introduced into our model. As noted previously, the population growth rate was calibrated form the HFCS by taking the average difference between each age cohort. By way of this, of course, the first moment is matched perfectly. However, the second moment is not. We assume a constant population growth rate which generates a linear age distribution. Yet, the age distribution observed in the data is hump-shaped[4]. To be more specific, the second moment for the population growth rate was 0.002 in the model, but, a staggering 0.35 in the data. This points to a shortcoming in our model.

4 Results

Experiment

The economy is initially in a steady-state equilibrium and people in this economy are all native. The government then decides to receive high-skilled immigrants at age 25 (first experiment), 40 (second experiment) or 55 (third experiment). In our model, this is represented by introducing a new type, "immigrant" (denoted by 1), who has high productivity. The size of the immigration inflow is represented by lambda, λ as a proportion of respective native cohort's share. In the initial steady state, government budgets are balanced, so pension benefits and transfer payments are found endogenously from the first (4) and second government budget constraints (5), respectively. Then in the final steady state, we take those transfer payments as given, and analyze what happens to the budget deficit. Despite our main focus being the budget deficit, efficiency and equity effects of immigration flows are analyzed as well. As a reminder, pension benefits in both states are found endogenously.

Table 1 illustrates key variables in the initial steady state and steady states with immigration. We ignore transitional dynamics from the initial steady state to the final steady state.

[4]The plot of the age distribution in the data can be found in appendix section 6.5

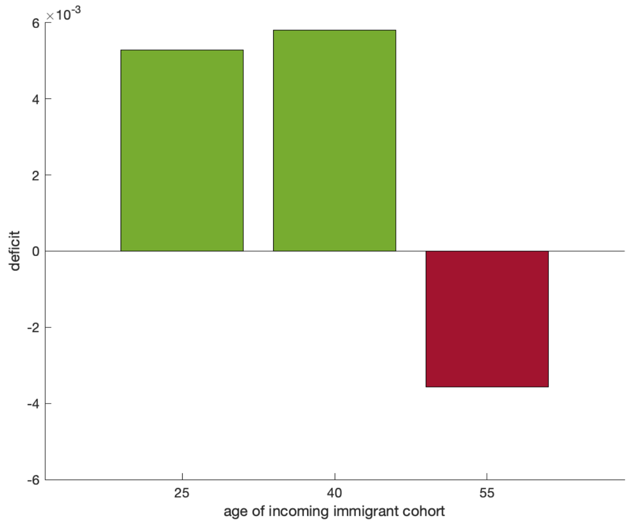

Figure 2: Deficit at Each Immigrant Cohort

Impact of immigration on the budget balance across 3 experiments

As we can see from table 1 and figure 2, budget balance turns to into a surplus in state (experiment) 1 and state 2, while a budget deficit is observed in state 3. The reason why state 2 has the highest positive impact on the budget balance seems to be driven by several factors. Firstly, compared with all other states, in state 2 the economy has more effective labor supplied, which ceteris paribus, increases government labor tax revenues. Higher effective labor supplied in state 2 can be associated with the efficiency profiles of immigrants; because productivity peaks between age 40 and 55, that means in the state 2 immigrants get to the peak productivity years as they enter the economy, quickly driving effective labor up. That means immigrants at age 40, have skipped this initial, less efficient part of their lives, so once they enter the labor market, they are immediately more efficient. Secondly, state 2 has accumulated more capital in comparison with state 1 and 3. This can be linked to the income effect, which means individuals earning more labor income due to high productivity save more as well. Since the optimality condition for the saving and consumption decision is identical in all states, higher saving in state 2 is not linked to the substituion effect. As a trade-off, in state 2 immigrants retire after 26 years, while this period is much longer in state 1. This cost of retirement can be seen in the pension benefits; in state 1 the government is able to pay higher pension benefits than in state 2, with the same pension tax rate. It is important to remember that in our model the pension benefits are fixed, but if those benefits are linked to income, then perhaps the picture may change in favour of state 2 again. Since the government would give less pension benefits to immigrants who have worked since the age of 40 than the ones who have worked since the age of 25, pension benefits for native people may still be higher in state 2.

In the following sections, a comparison of each experiment with the initial steady state is done.

Variable	Initial steady state	Experiment 1	Experiment 2	Experiment 3
A	–	1	16	31
t	0.12	fixed	fixed	fixed
b	0.11	0.12	0.11	0.09
w	1.26	1.27	1.28	1.27
r, %	4.15	3.98	3.92	4.07
K	1.81	1.93	1.96	1.77
L	0.27	0.28	0.28	0.26
Y	0.50	0.53	0.53	0.49
K/Y	3.60	3.67	3.70	3.64
h, %	38.16	38.13	38.66	38.84
D	0	0.0053	0.0058	-0.0036
Gini	0.17	0.20	0.24	0.17

Table 1: Changes in aggregate variables, prices, and welfare across steady states (Initial steady state - no immigration, Experiment 1 – immigrants enter at age 25, Experiment 2 – immigrants enter at age 40, Experiment 3 – immigrants enter at age 55, A– age of immigration, t– lump-sum transfers, b – pension benefit, w – wage, r – interest rate in %, K– aggregate capital, L– aggregate effective labor supply, Y– output, K/Y – capital to output ratio, h – average hours worked in %, D – deficit (or surplus), Gini - Gini index disposable income

Immigration at age 25

We first investigate the impact of allowing for high-skilled immigration at age 25. Key model parameters in the initial steady state and the percent each changed when immigrants entered the country at age 25 can be found in table 2. This is the same age at which natives enter the labour market. Compared with the initial state, aggregate effective labour L and capital K rise by 6.78% and 3.86% respectively, which can be linked to the reason mentioned above: high productivity. Specifically, aggregate effective labor supply increases since workers are now more efficient and can therefore produce more at constant hours worked. This is again echoed by the fact that the average hours worked h does not change, but the aggregate labor supply still increases. Workers can now earn better wages w and generate more effective labor for the same proportion of hours worked.

As a result, we see that the government budget balance turns into a surplus, with D changing from 0 to 0.0053. Labor-to-capital ratio, L/K, decreases by 2.7%, leading to an increase in the wage by 0.94% and a reduction in interest rate. Though we understand this may not be captured in our model, another underlying mechanism for the wage increase could be that when firms have full information they know the efficiency of both groups and increase wages to match the respective efficiency profile. If firms do not have full information they will still increase wages. This is due to the fact that immigration policy is aimed at high-skilled immigrants, even without full information the policy provides a price signal to the firms leading them to still pay a higher wage premium.

Since inputs increase, we observe 4.86% increase in output, which means the economy becomes more efficient. However, we see that the Gini index rises by 19.35 %, which means the reform leads to an increase in inequality. This can be related to the introduction of high-skilled workers in the economy as they are able to supply more effective labor. Additionally, since the wage rate increases, these

Reform	b	w	K	L	Y	Gini	D
steady state	0.11	1.26	1.81	0.27	0.50	0.17	0
Imm. at 25	+4.90	+0.94	+6.78	+3.86	+4.86	+19.35	+0.0053

Table 2: Key model variables in the initial steady state and when immigrants enter the country at age 25. Changes are represented as % change except for D. D is representd as an absolute change.

high-skilled workers are not only more efficienct but also earning more which leads them to have a higher disposible income. If the increase in disposible income is not matched by the increase in the pension benefit, then this may lead to more inequality between retierees and workers causing the Gini index to increase.

The pension benefits b increase by 4.9% as both the wage rate and aggregate labour supply increase. As the pension system is run as a pay-as-you-go, a higher wage rate and/or higher labour supply leads to an increase in the taxes collected by the pension system. This is then distributed to the retirees and leads to higher benefits paid out.

It is important to note that the changes noted here are entirely due to the increase in efficiency. Because our population distribution is normalized to 1 and both the immigrant and native population grow at the same constant rate, including the immigrants at the very beginning (age 25) of that distribution changes only the efficiency make-up of the population and not the age distribution.

Immigration at age 40

Next our paper analyzes an immigration policy targeting middle-aged high-skilled immigrants, specifically, immigrants entering the labour market at age 40. Key model parameters in the initial steady state and the percent each changed when immigrants entered the country at age 40 can be found in table 3. Again our results show that high-skilled immigration leads to a budget surplus (a positive D) of 0.0058. Here it is important to note that the efficiency of the immigrants is key. When setting immigrant efficiency equal to native efficiency (i.e. making immigrants not high-skilled), there is an almost negligible government surplus of 0.0005. This means that just increasing the proportion of 40 year olds (or instituting a policy where 40 year old immigrants of the "native" skill group can enter) will not generate the same effects and points to the fact that the policy must be for high-skilled immigration.

Compared to the initial steady state, there are higher levels of aggregate capital K and labour $L$and, accordingly, output Y. The percent increase over the initial steady state is now at 8.25%, 4.08%, and 5.44% respectively. The reasons for this are stated above. The wage rate $w$increases by 1.29% and the reasons for this are discussed in the section for state (experiment) 1.

What may seem a little counterintuitive is the decline in pension benefits b of 1.45%. As there is an increase in both the wage rate and aggregate labour supply, one may expect an increase in the benefits. However, as the immigrants are entering later in their lifecycle, the age distribution becomes more skewed to the tail end, resulting in a greater proportion of retirees receiving benefits sooner.

Reform	b	w	K	L	Y	Gini	D
steady state	0.11	1.26	1.81	0.27	0.50	0.17	0
Imm. at 40	-1.45	$+1.29$	$+8.25$	$+4.08$	$+5.44$	$+42.68$	$+0.0058$

Table 3: Key model variables in the initial steady state and when immigrants enter the country at age 40. Changes are represented as % change except for D. D is representd as an absolute change.

Reform	b	w	K	L	Y	Gini	D
steady state	0.11	1.26	1.81	0.27	0.50	0.17	0
Imm. at 55	-14.96	$+0.44$	-1.96	-3.30	-2.85	$+2.11$	-0.0036

Table 4: Key model variables in the initial steady state and when immigrants enter the country at age 25. Changes are represented as % change except for D. D is representd as an absolute change.

This increase in the proportion of retirees leads to an overall decrease in the pension benefit. It is this immigration policy where the Gini index is the highest, at an increase of 42.68% and this can be linked to the introduction of high-skilled immigrants at their peak earning profile.

Immigration at age 55

Finally, our paper investigates the impact of immigrants entering the labour market near the end of working life at age 55. Key model parameters in the initial steady state and the percent each changed when immigrants entered the country at age 55 can be found in table 4. This policy of older immigration leads to a budget deficit D of -0.0036. The deficit is a result of the decrease in aggregate capital K and labour L which decrease 1.96% and 3.30% respectively. Since transfers t are fixed, this decrease forces the government to run a deficit. The level of aggregate capital decreases since the proportion of agents near the end of their life cycle increases, thus a larger amount of agents are unable to accumulate as much lifetime capital. Additionally, workers only enter the labor market when their efficiency has already declined. Therefore, the aggregate labor supply decreases. Here, the output Y decreases as well by 2.85%. This is due to the reasons mentioned above–the workers are entering the labor market later and already not as efficient as before.

Pension benefits b are the lowest with this immigration policy, furthermore, they are lower than the steady state levels having decreased 14.96%. Again this is due to there being a larger proportion of retirees sooner. Furthermore, as these agents are entering the labour market near the end of their life cycle, their lifetime contributions to the pension system are lower than that of agents arriving at 25 and 40. The decrease in the aggregate level of labour is an additional cause for the decrease in pension benefits.

The Gini index is the lowest in this scenario than the previous other immigraiton policies, however, it is still higher than the steady state level, but only by about 2.11%. It is actually intuitive and consistent with previous cases; since new type of workers introduced in the economy is not much different that native ones in terms of efficiency, we see very slight change in Gini index.

5 Conclusion

Our paper's results are consistent with the literature: high-skilled immigration leads to positive fiscal effects. However, our model is a relatively simplistic model and lacks features that could potentially change our findings. With a greater amount of time our model could be expanded to include some of these features and some extensions not included in the literature. One extension that would be interesting to investigate is the effect of the composition of sex of both native and immigrants. As it has been heavily detailed in the labour economic literature, females face wage discrimination which results in lower wages. A possible extension to our model would be to investigate the changes of the proportion of females in both the native and immigrant population. This could lead to more muted impacts of immigration as one of the key aspects of it is the increase in the wage rate.

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6 Appendix

6.1 *Formula for $l^*_{j,s}$*

$$l^*_{j,s} = \left(\frac{\gamma * w * e_{j,s}(1-\tau_l-\tau_p) - (1-\gamma)[(1+(1-\tau_k)r)k_s + t - k'_s]}{(1-\tau_l-\tau_p)we_{j,s}} \right)$$

Parameter	Description	Value	Source
Demographics:			
J	life span	61	real-life age 85
J^R	retirement age	42	real-life age 67
n	population growth rate	0.0068	HFCS
Immigration:			
λ	immigration coefficient	0.3	about 400,000 immigrants
A	age of immigrant arrival	$\{1, 16, 31\}$	real-life ages 25, 40, and 55
Utility and Technology:			
σ	degree of relative risk aversion	2	Akin, 2012
α	share of capital	0.33	Busch et al., 2020
δ	depreciation rate of capital	0.05	Busch et al., 2020
Labor Productivity:			
$\{e_{j,s}\}$	age-efficiency profile	Figure 1	HFCS
Government:			
τ_k	capital income tax rate	0.25	Busch et al., 2020
τ_p	social security tax rate	0.093	PWC, 2022
τ_l	labor tax rate	0.296	OECD, 2021

Table 5: Model Parameters Determined Outside the Model

Parameter	Description	Value	Target
γ	relative weight on consumption	0.455	average labor supply = 38% (HFCS)
β	discount factor	0.988	$K/Y = 3.6$ (Busch et al., 2020)

Table 6: Model Parameters Calibrated Inside the Model

6.2 *Model Parameters*

Table 5 and Table 6

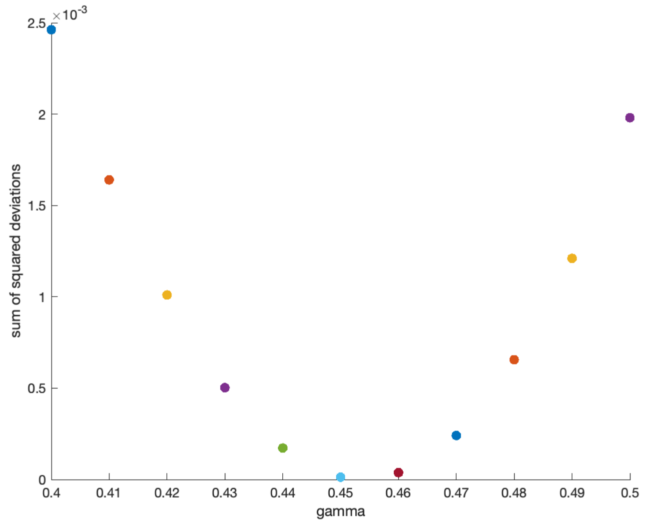

Figure 3: Sum of Squared Deviations for the Calibration of γ (relative weight on consumption)

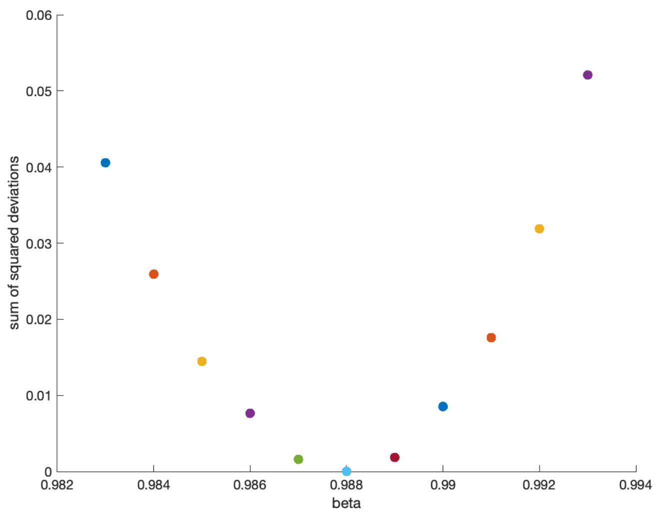

Figure 4: Sum of Squared Deviations for the Calibration of β (discount factor)

6.3 *Calibration Plots for γ and β*

Figure 3 and Figure 4

6.4 *The Immigrant Wage Gap*

The immigrant wage gap has been well documented. This holds true for Germany and high-skilled immigration. Studies such as Constant and Massey (2003) and Thomsen, Gernandt, and Aldashev (2008) which focus on Germany have shown that human capital transfer is imperfect and leads to a persistent wage gap between Germans and their immigrant counterparts. Thomsen, Gernandt, and Aldashev (2008) estimate that the wage gap across skill levels is about 11.3% for men and 20.0% for women. Therefore, in our model, any results found, given the assumption that immigrants and natives earn the same wages, will be an overestimation.

However, taking this into account and running our model with a 10% decrease[5] in the age-efficiency profile for high-skilled immigrants, produces similar (albeit less pronounced) results.
Additionally, evidence shows that, in the long-run, this wage gap decreases dramatically (Brunow & Jost, 2021). Thus, even if our assumption may lead to an overestimation of our results in the short run, in the long-run our assumption is justified and our results should be accurate.

[5]We chose a decrease of 10% based on the fact that the wage gap for high-skilled immigrants is less than the wage gap for immigrants across all skill levels (Brunow & Jost, 2019).

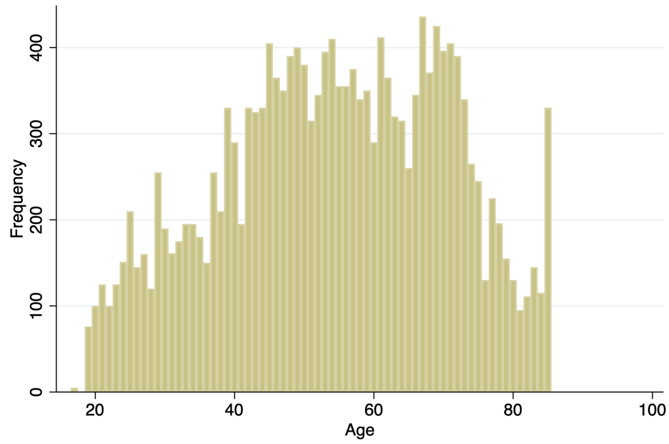

Figure 5: Age Distribution in the HFCS data set

6.5 *Age Distribution in the Data*

Figure 5

Contribution Statement:

- Nargiz Ahmadova worked on sections 1 (introduction except the related literature section), 2 (model environment), 4 (results, the deficit section), and double (and triple) checked the code
- Julia Fest worked on sections 3 (calibration), 4 (results, the specific age sections), made the matlab and STATA plots, and finished and finalized the code
- Rudy Uhl worked on sections 1 (introduction, the related literature section), 4 (results, the specific age sections), 5 (conclusion), and wrote the initial code for the initial steady state and the steady state with immigration

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"I hereby take an affidavit that I have completed the above examination independently and without unauthorized outside help and without the use of unauthorized aids. I am aware that the violation of the examination regulation on cheating when performing examinations according to § 63 sec 5 Higher Education Act of North Rhine Westfalia constitues an administrative offense and the submission of an incorrect affidavit is punishable as a criminal offense."

Date, Place, Signature

28.02.2022 Bonn

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Feb 28th, 2022, Bonn,

Date, Place, Signature (handwritten)

Please note: If you only submit this affidavit electronically as a scan or photo, keep the original for evidence purposes. The signed original can still be requested after verification.