The costs of building walls: Immigration and the fiscal burden of aging in Europe*

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Abstract

By how much can immigration relieve the burden of aging on public finances in Europe? Combining multiple survey data sources we estimate the demographic profile of the government budget and build customized population projections for each country of the Euro area, by age, gender, skill level, and country of birth groups. We then compute the fiscal imbalances implied by aging. Keeping net migration at its 2019 level, we find that restoring fiscal balance requires a permanent tax increase of 13.9 percent across all countries. Furthermore, we find that the relationship between the size of the net migration flows and the fiscal burden of aging is negative, nonlinear, and convex. Building walls has high costs: setting net migration to zero would increase this measure by 2.6 percentage points. In contrast, increasing migration helps in closing the gap but cannot by itself entirely close the gap. Still, the potential of migration largely outweighs that of increasing fertility. These results do not rely on higher immigrant fertility.

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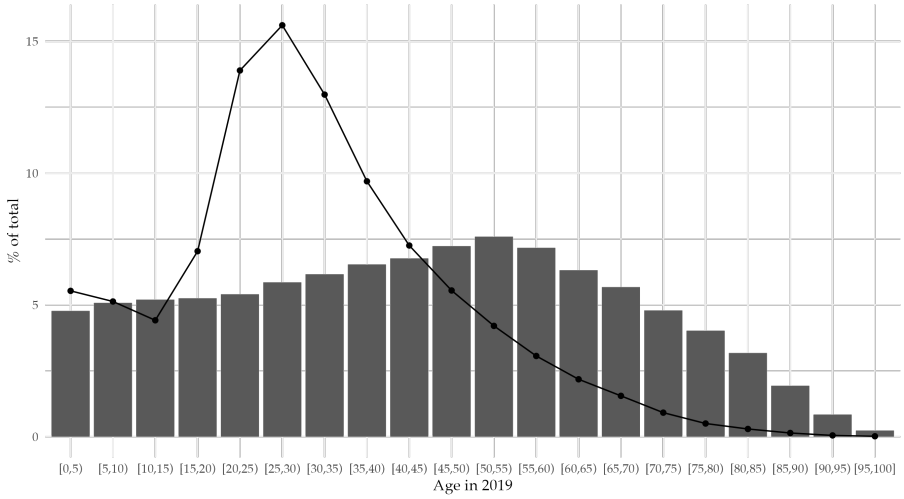
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1 Introduction

Population aging is a major concern for developed economies, particularly in Europe. Over the last decades, fertility rates have fallen, and as life expectancy continues to rise, the population share of working-age individuals has shrunk. In Europe, the old-age-dependency ratio – the ratio of the 65-plus to 20- to 64-year-old population – is projected to increase by more than 20 percentage points, from 34.8 percent in 2019 to 56.7 percent in 2050 (Eurostat, 2020). Absent any adjustment, these trends represent a burden for public finances – the fiscal burden of aging. Revenue from social security contributions and income taxes falls as the share of the working-age population decreases. At the same time, public spending grows, namely on retirement benefits and healthcare services, primarily consumed by the elderly.

Immigration often appears in public debate as a remedy for the fiscal burden of aging. Indeed, as Figure 1 shows, individuals immigrating to the European Union (EU) in 2019 were much younger than the existing resident population. Crucially, current immigration flows to Europe are concentrated in the working-age group, unlike the resident population stock. By rejuvenating the population and enlarging the labor force, immigration could help relieve the fiscal burden of aging. Yet, political platforms that portray it as a problem are gaining more and more traction. Many European countries are discussing policies to contain or even cut down immigration from the developing world.

Figure 1: Age Distribution of the Population Stock and the Immigration Flow to the EU in 2019



Note: Each gray bar represents the percentage of the resident population in the EU belonging to a specific age group in 2019. The solid black line represents the percentage of immigrants arriving in the EU from outside the union in 2019, also segmented by age group.

In this paper, we study how restricting or expanding migration inflows can affect public finances in the Euro area (EA), focusing on their resilience to aging. We find a nonlinear relationship between the size of the net migration inflow and its impact on public finances. Restricting immigration could increasingly strain public finances by exacerbating the expected rise in the age-dependency

ratio. Conversely, expanding migration inflows yields diminishing returns for public finances, as the effects of such an expansion on the age structure of population are limited.

These conclusions draw from a classic result in demographic modeling. In populations where native fertility rates are below the replacement level, like in much of Europe, immigration is vital not only for stabilizing population dynamics and preventing decline, but also for maintaining a balanced age-dependency ratio in the medium term.

Building on these theoretical insights, we further explore the implications for public finances through an empirical application. Using multiple survey data sources, we estimate demographic profiles of taxes and benefits segmented by age, gender, skill level, and country of birth, within the EA. We combine these data, covering the complete government budget, with customized population projections.

With these data, we measure the fiscal burden of aging. In line with the generational accounting (GA) tradition, we compute a counterfactual government budget series, by keeping the demographic profiles of taxes and benefits fixed and applying them to our population projections. The fiscal burden of aging is measured by calculating the tax increase required to ensure public debt sustainability under this counterfactual budget. By producing this measure under different scenarios for net migration, we trace out the role of migration flows in mitigating the fiscal burden of aging.

As of 2019, the EA aggregate primary balance had a small deficit of 0.2 percent of the potential GDP, due to a positive net contribution from non-EU immigrants. Without their contribution, this small deficit would have been larger. Projecting into the future, if we held the current demographic profiles of taxes and benefits constant, with population aging as forecasted, the primary deficit would become 8 percent of the potential GDP by 2060 and 9.6 percent by 2100. In this scenario, to ensure fiscal sustainability, on average, European countries would have to permanently increase the tax burden by 13.9 percent.

These baseline results rely on sustaining the positive net migration inflow of 2019 in the future, both in its overall size and current age-skill structure. In this year, the net migration inflow to the EA was about 0.4 percent of the total population (around 1.33 million people). Cutting this flow down to zero would lead to a much larger fiscal burden of aging: an average permanent tax increase of 16.5 percent across the EA would be required to ensure fiscal balance (which corresponds to an increase of 2.6 percentage points). Conversely, doubling the net migration flow would result in a 1.5 percentage point decrease in the rebalancing tax increase.

We find a nonlinear relationship between the size of net migration flows and the rebalancing tax increase. The effects of reducing the net migration flow grow with the restriction's size. In contrast, increasing the net flow of migrants has a decreasing beneficial impact on the rebalancing tax increase. These results are robust to different assumptions for the fertility rates of immigrants and their descendants, as well as for macroeconomic parameters. This nonlinearity has its roots in demographic dynamics, which generally apply to any population where native fertility is below replacement and there is a constant inflow of working-age migrants.

Restrictions on immigration from outside the EU have become a focus of political debate in many European countries. Our results show that policymakers considering such restrictions risk worsening the fiscal burden of aging for their constituents, because of the effects of immigration on demographic dynamics. Nevertheless, fostering immigration cannot, *per se*, solve the fiscal gap caused by aging. We confirm this conclusion, while adding that this result is rooted in the non-linearity that we uncover. We also show empirically that at current levels of immigration, there is still room for gains from increasing net migration inflows, in reducing the fiscal burden of aging in Europe.

Related literature and contribution Our paper makes two main contributions. First, we show that the impact of immigration on the fiscal burden of aging is non-linear. The preceding literature has used three different approaches to investigate the contribution of immigration to public finances: fiscal accounting (e.g. Auerbach and Oreopoulos, 1999, Storesletten, 2003, and Dustmann and Frattini, 2014), general equilibrium models (e.g. Storesletten, 2000; Fehr et al., 2004; and Hansen et al., 2017), and time-series models (e.g. D'Albis et al., 2019 and Furlanetto and Robstad, 2019). Our paper can be inscribed in the first of these groups, and confirms previous results suggesting immigration has a small, positive effect in relieving the fiscal burden of aging – see Preston (2014) for a review. However, our paper refines the approach and is the first, to the best of our knowledge, to document the non-linearity in the link between immigration and the fiscal burden of aging.

Second, we apply our methodology to all Euro area countries, reporting updated cross-country estimates of the fiscal burden of aging, and of the potential of immigration to reduce it. This is not only relevant for policy makers, but also for researchers addressing related topics, considering the lack of recent studies offering comparable results across European countries. The exceptions are Fiorio et al. (2023), who compute the fiscal net contributions of immigrants in Europe between 2014 and 2018, and Christl et al. (2022), who provide medium-term projections of those contributions, but do not speak to their aggregate fiscal impact, nor to how they might change with the intensity of immigration flows.

Organization The rest of the paper is organized as follows. Section 2 describes the accounting methodology used to assess the impact of aging on public finance. Section 3 describes the data and some implementation details. Section 4 presents the budget balance decomposed by different demographic characteristics and our customized population projections. Section 5 describes the results on the role of migration in European public finances, and Section 6 concludes.

2 Measuring intertemporal fiscal imbalances

Our methodology is based on the seminal work of Auerbach et al. (1991), who proposes GA as a meaningful alternative to standard public accounts that consider how demography affects pub-

lic finances. In this section, we show how to map the budget aggregates into different demographic groups to estimate the demographic profiles of the budget. We also show how we build our customized population projections. We then compute the budget implied by these population projections, under the estimated demographic profiles. Last, we derive an imbalance metric that corresponds to the permanent tax increase needed for the public finances to be sustainable.

2.1 Mapping Budget Aggregates to Demographic Groups

Government faces a yearly nominal budget constraint, where government bonds at the end of a period are equal to the sum of the primary deficit with the government debt of the previous period plus the interest paid on that debt:

$$B_t = G_t - T_t + (1 + i_t)B_{t-1}, \tag{1}$$

where B_t is government debt in period t, G_t is total public expenditure net of interest payments on the outstanding debt in period t, T_t is total revenues received in period t, and i_t is the implicit nominal interest rate paid on the debt during period t.

Total revenues and expenditures are sums of different revenue categories, such as different types of taxes and social benefits, respectively. Each total is an aggregate of its respective categories. As we want to understand the impact of demographics on public finance, we map each budget category, i, to a demographic group, x. Government revenues in a year t can be expressed as

$$T_t = \sum_i T_t^i = \sum_i \sum_{x \in X} \tau_{t,x}^i P_{t,x}, \tag{2}$$

where $\tau_{t,x}^i$ is the average per capita government revenue of category i that is attributed to an individual of cohort x in the year t, and $P_{t,x}$ is the number of individuals of cohort x alive in year t. Similarly, government expenditures in a given period t can be expressed as the sum of all expenditure items, G_t^i, across all demographic groups:

$$G_t = \sum_i G_t^i = \sum_i \sum_{x \in X} g_{t,x}^i P_{t,x}, \tag{3}$$

where $g_{t,x}^i$ is the average per capita government expenditure of category i attributed to a person of cohort x in year t. We refer to $\tau_{t,x}^i$ and $g_{t,x}^i$ as the demographic profile of revenue item i and expenditure item i, which correspond to the demographic structure of the government budget. In Section 3, we estimate them for the different EA countries using a combination of several microdata sources and macro aggregates.

2.2 Projecting towards the Future

To build a counterfactual path of the budget balance, we must project both total revenues and total expenditures over time. As shown in Equations (2) and (3), we need the population stock for each demographic group and the demographic profile of each budget item to compute the budget aggregates. In this subsection, we show how we project these two elements toward time.

For the first element, the population stock, we combine projections for the fertility rate, the mortality rate, and net migration. While long-run population projections are readily available from several statistical institutions, they do not possess the granularity that we need for our exercise. We consider that a demographic group corresponds to people with the same age a, gender g, country of birth c, and, as in Chojnicki and Rabesandratana (2018), skill-level k. We build our own projections using the cohort component method, which is standard in several demographic studies.[1] The population stock of a demographic group with age a, gender g, and country of birth c evolves according to

$$P_{t,a,g,c} = \begin{cases} (1 - m_{t-1,a,g,c})P_{t-1,a,g,c} + \bar{I}_{t,a,g,c}, & \forall a > 0 \\ \sum_{a,g,c} P_{t-1,a,g,c} f_{t-1,a,g,c} \lambda_t + \bar{I}_{t,a,g,c} & \text{for } a = 0 \end{cases} \quad \text{for } t > \bar{t}\ , \tag{4}$$

where $m_{t,a,g,c}$, $\bar{I}_{t,a,g,c}$ and $f_{t,a,g,c}$ correspond to the mortality rate, the net migration, and the fertility rate at time t of the population with characteristics a, g and c, respectively. λ_t is the gender breakdown of newborns in period t.[2] Afterward, we split each of these groups of the population by skill level, assuming that (i) for each individual, skill does not change after the age of 25 and (ii) the skill distribution observed at age 25 in the initial year is constant throughout time.[3]

For the second element, the demographic profiles, we set the growth rate of the path of nominal per capita revenue item i, for each demographic group x, to be the growth rate of labor productivity, γ, plus the inflation rate, π:

$$\tau^i_{t,x} = \tau^i_{\bar{t},x} \prod_{j=\bar{t}+1}^{t} (1 + \gamma_j)\,(1 + \pi_j)\ , \text{ for } t > \bar{t}, \tag{5}$$

and mutatis mutandis for government expenditure items. The dual macroeconomic model for this accounting framework is an endowment economy populated by overlapping generations of agents who differ across demographic characteristics, including age, where the endowment grows at a constant rate and population dynamics are deterministic, similar to Storesletten (2003). This would imply the same dynamics as the ones described above. In Appendix A we describe in detail this model.

[1] This method is used by the US Census Bureau and by Eurostat when building their population projections.

[2] We consider λ_t to be constant and equal to the value observed in the base year.

[3] These hypotheses can be seen as conservative projections, as the number of people attending higher education degrees has been increasing all over Europe.

2.3 Imbalance Metric

We next assess the implications of demography in public finances. For that we derive a metric to measure the intertemporal fiscal imbalances. We assume that the current demographic structure of the budget does not change except in size. It is important to note that we do not aim to accurately forecast the different budget aggregates, whose future paths certainly depend on many factors beyond demographics. Our goal is to quantify the fiscal imbalances created by aging and, by changing the demographic projection, the role of migration in closing them.

Following the GA literature, we define public finances to be balanced if the present discounted value of current and future revenues is equal to the present discounted value of current and future expenditures plus current debt, that is if the intertemporal government budget constraint (IGBC) holds. The IGBC is simply the sum, over infinite periods into the future, of the yearly budget constraint described in Equation (1), starting in the base year $\bar{t}$:

$$\sum_{s=0}^{\infty}\prod_{j=1}^{s}\frac{G_{\bar{t}+s}}{(1+i_{\bar{t}+j})}-\sum_{s=0}^{\infty}\prod_{j=1}^{s}\frac{T_{\bar{t}+s}}{(1+i_{\bar{t}+j})}+B_{\bar{t}-1}=\lim_{s\to\infty}\prod_{j=1}^{s}\frac{B_{\bar{t}+s}}{(1+i_{\bar{t}+j})}. \tag{6}$$

Let $D_t \equiv \frac{(1+\gamma_t)(1+\pi_t)}{1+i_t}$ represent a growth/discount factor, which we assume (for simplicity) is constant; that is, $D_t = D\ \forall t$. Following our definition of balanced public finances, we must have the limit on the right-hand side of Equation (6) equal to zero and the equation to hold. The first condition corresponds to a no-Ponzi game condition; that is, the public debt is not on an exploding path. For the second condition to hold, we introduce a wedge, $(1+\theta_\tau)$, which corresponds to a proportional adjustment factor to revenues. Given a set of demographic profiles at $\bar{t}$, future paths for the population of each country n and each cohort x, and a starting value for public debt $B_{\bar{t}-1}$, we can derive the adjustment factor, θ_τ:

$$\sum_{s=0}^{\infty}\sum_{i}\sum_{x\in X}D^s\left[g^i_{\bar{t},x}-(1+\theta_\tau)\tau^i_{\bar{t},x}\right]P_{\bar{t}+s,x}+B_{\bar{t}-1}=0. \tag{7}$$

The adjustment factor θ_τ represents the permanent increase, across all revenue categories, and cohorts, necessary to ensure intertemporal fiscal balance, keeping the same demographic structure of the budget. We refer to θ_τ as the rebalancing tax increase. Note that we do not assume any particular path for the public debt trajectory, except that the government pays it.

Before we proceed, let us discuss two technicalities of this adjustment factor. First, note that the same exercise could be performed by instead introducing an adjustment factor on government expenditure. This factor would represent the permanent change required in all expenditure categories to ensure the IBC holds. The results of doing so are symmetric, and therefore, for presentation purposes, we focus only on the rebalancing tax increase. Second, we are projecting the budget aggregates departing from a base year, $\bar{t}$, that carries two year-specific effects: (i) effects associated with the particular histories of cohorts alive in $\bar{t}$, such as wage trends or retirement choices, and (ii) business-cycle effects on the budget at $\bar{t}$, such as higher unemployment benefits due to $\bar{t}$ being

a recession year. To clean the latter effects, we use cyclical adjustments to fiscal aggregates, following the approach of Bonin et al. (2014) who apply the cyclically-neutral budget adjustments of Girouard and André (2006) to a GA exercise.[4]

The rebalancing tax increase is related with the dynamics of the total dependency ratio. To see that, note that θ_τ is positive when the contributions to the budget are larger than the benefits that the government pays over time. This has to do with the structure of the budget, given by the demographic profiles, $g^i_{\bar{t},x}$ and $\tau^i_{\bar{t},x}$, and with the number of people with positive net contributions to the budget. In our framework, the first is constant over time; hence the larger contribution comes from the population dynamics. The ratio of dependents (young and old individuals) over the working-age population provides the inshight of the proportion of net contributors in the total population, and hence the relationship between $\theta_\tau$and the dependency ratio.

Metrics for comparison For comparison purposes with other studies that have been done on the impact of demographics on public finance, we also report two other imbalance metrics. The first metric is the one used in traditional GA studies following Auerbach et al. (1991) (θ^{AGK}_τ), which distinguishes between presently living and unborn generations. This metric represents the permanent change in revenues solely attributable to future generations – the generation born after the base year – while taxes for current generations remain unchanged.[5]

The second measure commonly reported is the intertemporal budget gap (IBG). This metric does not rely on a definition of intertemporal fiscal balance and instead simply sums the projected budget deficits, reported as a ratio to GDP in the initial period ($Y_{\bar{t}}$). This metric provides insights into the size of future liabilities arising from aging.[6] We show these two measures in Section 5, alongside the rebalancing tax increase.[7]

3 Data

In this section, we describe the data sources we use as well as the implementation details of the accounting methodology described in Section 2. With that, we estimate the demographic profiles of the different revenue and expenditure items and build our customized population projection for each EA country, by age, gender, skill level, and country of birth.

3.1 Data Sources

We must build two objects: the set of demographic profiles for various budget items for the universe of EA countries, and the demographic projections for each cohort x for all EA countries. The

[4] In Appendix C.1, we describe these adjustments in greater detail.

[5] The generational distribution of the fiscal burden of aging it implies is likely very unrealistic. Furthermore, the metric is very sensitive to the value of D. See Rowthorn (2008) for a discussion.

[6] This metric suffers from the same issues as the debt-to-GDP ratio, where we compare a stock with a flow.

[7] In Appendix C.2 we show the formulas to compute these two metrics.

first object requires individual micro-level data with the demographic characteristics of individuals, their contributions to each tax, and their benefits from each social subsidy and public service. Furthermore, we want our exercise to be consistent with the national accounts. As such, we need the macro-aggregate values of the different budget items. For the second object of the population projections, we need forecasts for fertility, mortality, and net migration by age, gender, and country of birth. Moreover, we also need to know the skill distribution for the initial period.

Individual microdata on taxes and benefits come mostly from the EU Statistics on Income and Living Conditions (EU-SILC) survey. This data set aims to collect timely and comparable cross-sectional and longitudinal data on income, poverty, social exclusion, and living conditions. We use cross-sectional individual data on labor income, income and property taxes, and social transfers, including pensions and demographic characteristics to estimate $\tau_{\bar{\imath},x}$ and $g_{\bar{\imath},x}$. This covers most of the spending and revenue items that we map to different demographic characteristics.

To achieve a more complete coverage of the government budget, we use two additional microdata sources. We obtain household-level data on consumption from the Household Budget Survey (HBS), in order to derive the demographic profile of consumption, used to allocate value-added tax. We also use the European Central Bank's Household Finance and Consumption Survey (HFCS) data on household business wealth holdings, which we take as a proxy measure for the incidence of corporate income tax.[8]

For healthcare spending, we obtain an age-gender profile of government health expenditure reported directly by the European Ageing Working Group (European Commission, 2018). For education, we use data from Eurostat that report expenditures by level of studies. This allows us to map level of studies to an associated age group. Appendix D, summarizes these different microdata sources.

Macrodata on public revenues and expenditures, as well as on government assets and liabilities, are retrieved from Eurostat. In all cases, we refer to data for the general government sector. For the interest rate, i, we compute the historical average implicit rate from the outstanding stock of public debt. We also obtain data on labor productivity, to compute γ, and on the inflation rate, to compute π, using the time average from 1995.

Demographic data also come from Eurostat, where we obtain population breakdowns by skill and country of birth. Specifically, we use the EUROPOP2019 central projection to obtain forecasts for mortality and fertility rates (Eurostat, 2020).

3.2 Implementation

We choose 2019 as our base year, which corresponds to the year of the data where we estimate the demographic profiles as well as the starting year for the population projections. We choose this base year for two reasons. First, it is the latest complete year of data before the COVID-19

[8]Corporate income tax is paid by firms on their profits. However, ultimately, firms belong to households and hence we use the households' business wealth holdings distribution as a measure of the incidence of this tax on individuals.

pandemic, and hence the data are not contaminated by effects specific to the health crisis, affecting both the life-cycle profiles of taxes and benefits and the demographic data. Second, it allows our exercise to be in sync with the starting year of the EUROPOP2019 population projections. Nevertheless, we conduct robustness checks for other choices of the base year. We perform our estimations for the 19 countries that were part of the EA in 2019.[9]

The methodology takes the total revenue and total expenditure and breaks it down into different budget categories. It then decomposes the value of each item by age, gender, skill, and birthplace. However, the breakdown cannot be performed for every item in the government budget, due to data limitations and conceptual reasons. Benefits from government activities such as defense, justice, or regulation do not vary among individuals, as they are a public good that, by definition, is nonexcludable. For these reasons, we distinguish mappable items from uniform items. For the first group of items, which covers roughly two-thirds of the government budget in 2019, we estimate the demographic profiles. This group consists of five taxes (personal income tax, corporate income tax, value-added tax, social security contributions, and property tax) and seven spending items (old-age pension, disability pension, survival pension, sickness allowance, unemployment subsidy, education services, and healthcare services). For the revenues of the second group, we uniformly distribute them to all individuals older than 18 years, and for the expenditures, we distribute them uniformly, independent of any demographic characteristic.[10] In Appendix C.3 we describe the estimation of the different profiles.

In terms of demographic characteristics, our accounting framework considers ages between 0 and 100, where 100 corresponds to individuals who are 100 or more years of age, and two genders (male and female). Regarding skill level, we consider three different levels: skill level 1, which corresponds to having completed lower secondary education or below (ISCED 2 and below); skill level 2, which corresponds to having completed upper- and post-secondary education (ISCED 3 and 4); and skill level 3, which corresponds to having obtained a college degree (ISCED 5 and higher). Finally, we consider two groups in terms of birthplace: those born in the EU and those born outside the EU. Appendix C.4 describes how we build the population projections.

We assume that mortality rates are the same for individuals of the same age and gender living in the country. In other words, these rates do not vary across different skill levels or country of birth. For the fertility rate, we have different assumptions, dependent on the country of birth. For those born in the EU, we directly use Eurostat forecasts that project a slight increase in the fertility rate until 2100, but always below replacement. For those not born in the EU, we set a linear downward convergence path aiming to reach 2.1 by the year 2100. Furthermore, the second generation of immigrants has the same fertility rate as their parents.[11] Similarly to Section B, we

[9] They are Austria (AT), Belgium (BE), Cyprus (CY), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), Malta (MT), the Netherlands (NL), Portugal (PT), Slovakia (SK), Slovenia (SI), and Spain (ES).

[10] This distinction is mostly for presentation purposes and does not materially affect the results. In any case, the rationale is that children, while unable to earn any income and thus not bearing the burden of taxation until they reach working age, can and do benefit from public services since birth.

[11] These assumptions do not affect our results as we show in Appendix E.2.

set the immigration flow to be constant and equal to the value observed in 2019.

Furthermore, our accounting framework implies projecting the population toward a very distant future. In practice, we use the population laws of motion in the system of Equations (4) until 2100, and after that year, we assume a full stationary population distribution.[12] This simplification, together with $D \in (-1, 1)$ implies that we can solve equation (7) for the rebalancing tax increase, where the infinite sums are convergent geometric series.

4 Demographic Profiles and Population Projections

In this section, we discuss the estimation results of the demographic structure of the EA government budget primary balance of 2019. We also discuss the population projection that we use to forecast the counterfactual evolution of the primary balance and, ultimately, to assess the role of immigration in the public finances balance.

4.1 Primary Balance Decomposition

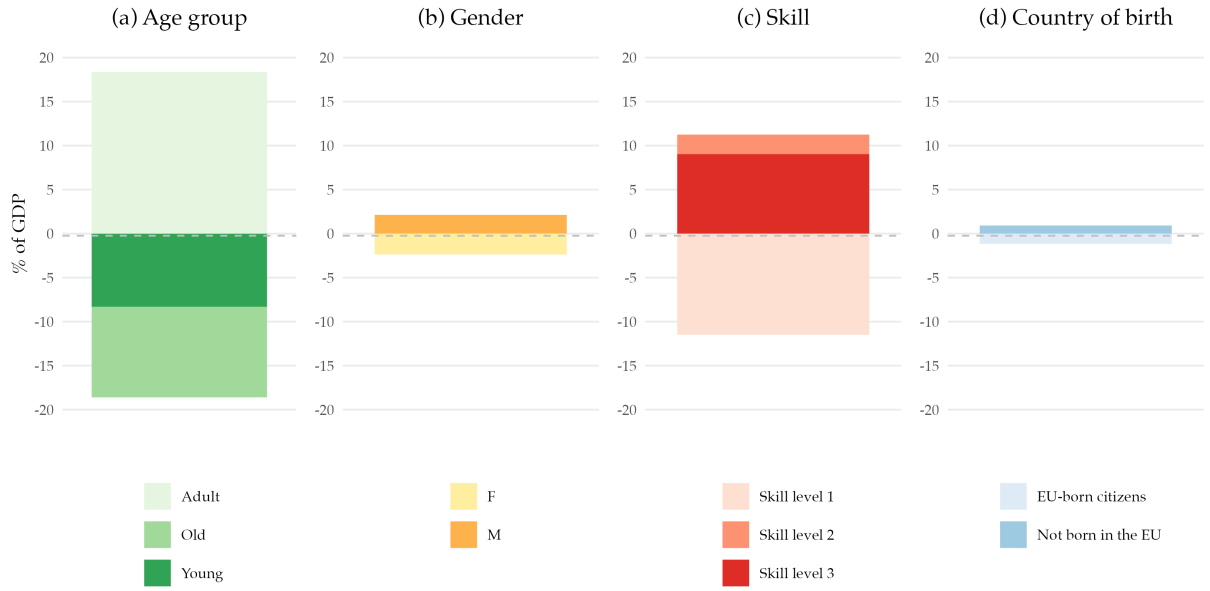
Using the microdata sources described in Section 3, we estimate the tax and benefit distribution by age, gender, skill level, and country of birth, for each country in the EA. With these objects we are able to decompose the primary balance along these four dimensions for the base year, 2019. This allow us to understand the demographic structure of the budget, as for example how much a 45-year-old man born outside the EA with a high school degree, on average, pays on personal income tax in the base year. Moreover, it allows us to decompose the base year's primary balance by the different demographic characteristics, that is, age, gender, skill level, and country of birth. Figure 2 shows that decomposition for the EA as a whole.[13]

When we decompose the primary balance by age groups, we find that the young and the elderly populations are net receivers of the government budget, while the working-age population is a net contributor to the budget. Their contribution rises to more than 15 percent of the GDP. This pattern can be easily understood when we think about the life-cycle dynamics regarding taxes and social benefits. The young generation benefits almost exclusively from education expenditure, as they only start paying taxes when they enter the labor market, which for most people is in their 20s. Hence, their net contribution to the primary balance is negative. Although they pay some taxes, the older generation is a net receiver from the government budget due to the social benefits they receive, namely retirement pensions and healthcare. Finally, the adult population receives very little social benefits, except occasionally for events such as unemployment or sickness. However, they are the biggest taxpayers since income and consumption peak during the working years, making them net contributors to the government budget.

[12] The results are robust to the choice of 2100.

[13] Appendix F has a similar Figure but for each country of the EA.

Figure 2: Decomposition of the EA Primary Balance for the Base Year, 2019



Note: The figure presents the decomposition of the EA primary balance by demographic characteristics. It represents the sum of revenues, net of benefits, attributable to individuals with specific demographic characteristics, expressed as a percentage of the 2019 potential GDP. The dashed line denotes the 2019 value of the primary balance (-0.2 percent). All values are shown as a percentage of the potential GDP.

Examining the gender decomposition, we find that men are net contributors to the budget, whereas women are net receivers. This disparity arises for a few reasons. While education is the same for the two genders, the taxes paid are different due to the variations in income received. These variations may be due to differences in labor market participation rate or differences in salaries across genders. Furthermore, due to their longer life expectancy, women receive pension benefits and use healthcare services for a longer period compared to men.

Regarding the skill decomposition, individuals with lower skills have a net negative contribution to the budget. In contrast, those with skill levels 2 and 3 contribute positively yet not enough to achieve an overall positive primary balance. The underlying reason is similar to the male-female dichotomy: lower skills, means, on average, lower income, leading to lower tax contributions.

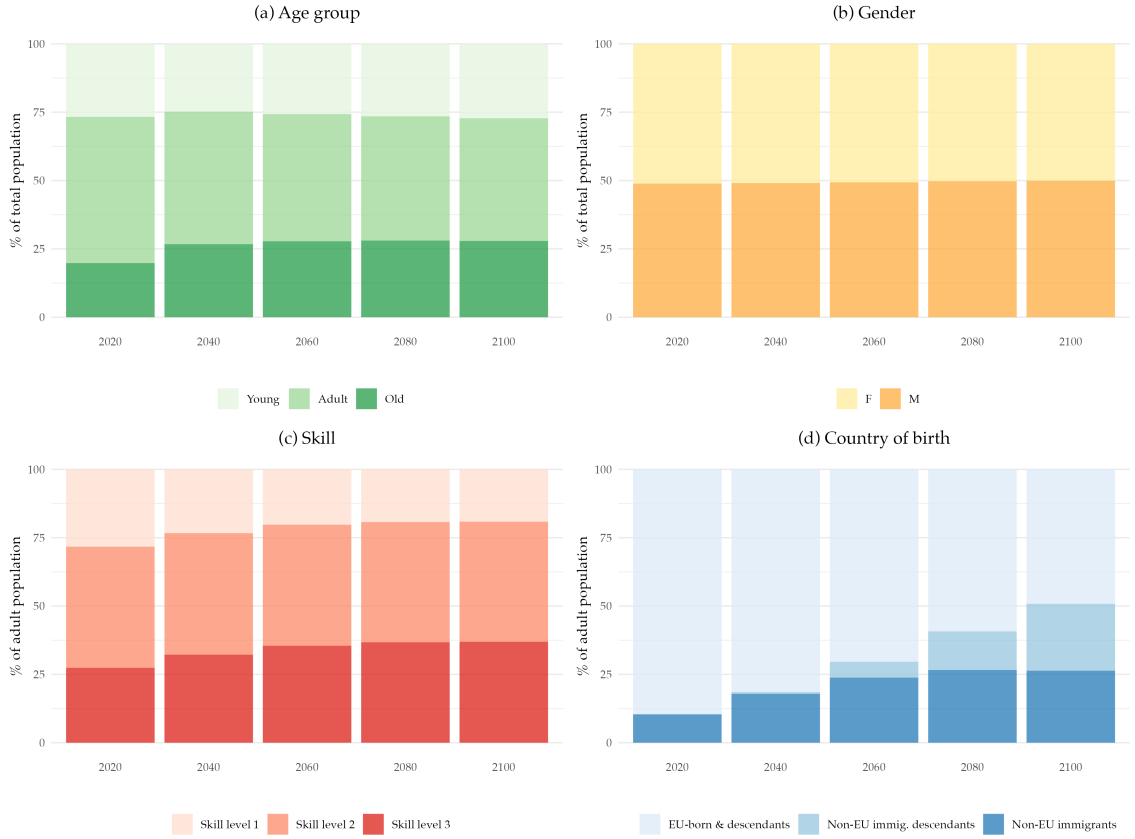
More relevant to our research question is the decomposition by country of birth. We find that those not born in the EU have a small but positive contribution, while EU-born individuals are net receivers of the public budget. This fact is linked to the younger age profile of immigrants, as shown in Figure 1. In 2019, immigrants already have a positive contribution to public finances as their absence would have resulted in a more negative primary balance.

4.2 Demographic Projections

As described in Section 2, a key object for our exercise is the detailed population forecast that will be used to project the government balance. For each country in the EA, we project the population stock by age, gender, country of birth, and skill level according to Equation (4), until 2100.

After that year, we assume a full stationary population. Figure 3 plots, for selected years of the projection, the implied EA age, gender, skill level, and country of birth distribution. Our population projections imply that the population will age. The dependency ratio (the ratio of the young and old populations to the adult population) increases from 0.89 in 2020 to 1.13 by 2100. Panel (a) shows that the share of the adult population decreases, while the share of the old population increases. The share of the young population first decreases, due to the low fertility rates, but then slowly recovers to its initial value as fertility slowly rises. The gender distribution, represented in panel (b), is projected to remain constant, with the female population making up slightly half of the total population.

Figure 3: Demographic Distributions Implied by the Population Projections



Note: The figure shows the percentage of people with given demographic characteristics. Panel (a) displays the age distribution by age group (young, adults, and old age). Panel (b) shows the gender distribution (female and male). Panel (c) presents the skill-level distribution as a percentage of the adult population, where skill level 1 corresponds to those who did not complete high school, skill level 2 corresponds to those who completed high school, and skill level 3 corresponds to those who completed college. Panel (d) depicts the distribution of country of birth as a percentage of the adult population.

Our demographic forecasts imply the skill distribution of the adult population will change, as panel (c) illustrates. The highest skill level is expected to increase by 12 percentage points, whereas the lowest will fall by about 10 percentage points, between 2020 and 2100. Last, panel (d) shows that the share of non-EU immigrants is projected to rise from 10 percent of the adult population to 26 percent. The children of this part of the population, which has a higher fertility rate, are projected to represent 25 percent of the adult population in 2100.

5 Immigration and Public Finance Sustainability

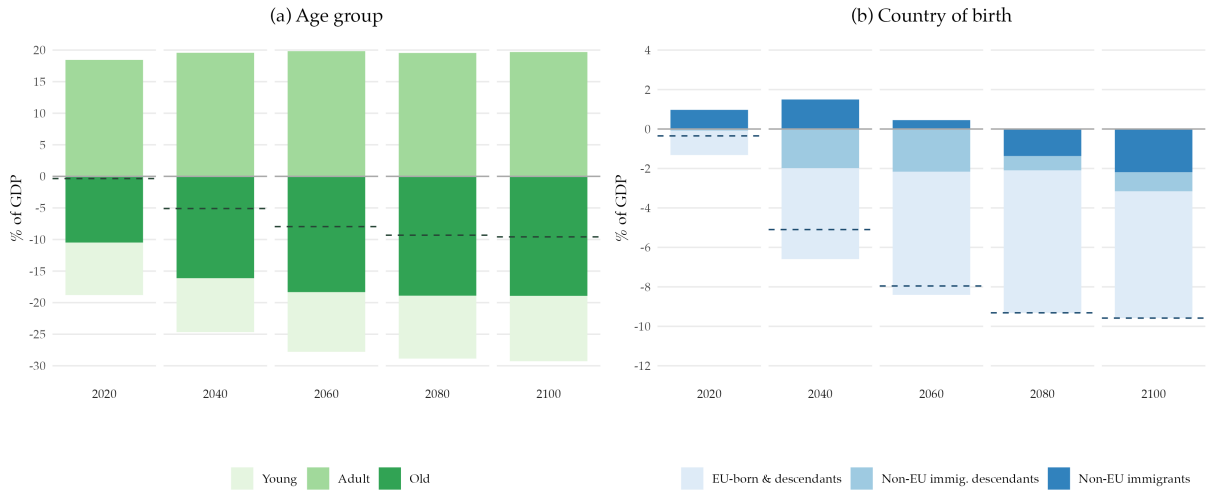
In this section, we look at our counterfactual government budget implied by the population projection. First, we use it to compute the rebalancing tax increase previously defined in Section 2 and look at the contributions of the different age and country of birth groups over time. This allows us to quantify the fiscal burden of aging, in a baseline migration scenario. Then, we present our main results on the impact of changing the non-EA net migration flow on public finances. The section closes with a list of robustness exercises that we perform.

5.1 The Fiscal Burden of Aging

As described in Section4, demographic projections until 2100 show that the population of the EA will age, with the dependency ratio increasing substantially. Other things equal, this trend is likely to put pressure on the sustainability of public finances. To quantify this fiscal burden of aging, we build the counterfactual government budget under our customized population projections, keeping fixed the demographic profiles of the different budget items.

In Figure4 we plot the resulting primary balances, for selected years of the projection. The current deficit of 0.2 percent of the GDP in 2019 widens over time. By 2040, the primary deficit would be 5.1 percent, and by 2100, it would be almost 10 percent of potential GDP. This transformation of the primary balance into a permanent deficit is robust to the starting point, as the same trend is observed for individual EA countries. See Appendix F for the projected primary balance of each country.

Figure 4: Counterfactual Primary Balance Implied by the Population Projections Decomposed by Age Group and Country of Birth



Note: The dashed lines in the figure represent the primary balance for selected years of the projection. Panel (a) shows the decomposition of the primary balance by age group (young: 0--24 years old; adult: 25--65 years old; and old: more than 65 years old). Panel (b) shows the decomposition of the primary balance by country of birth. All values are shown as a percentage of the potential GDP.

Under this counterfactual budget, by how much would the governments in the EA need to increase taxes to rebalance public finances? To answer this question, we look at our rebalancing tax increase, θ_τ, derived in Section 2, which is the increase necessary to ensure the IGBC holds. For presentation purposes, we compute the weighted average, using the 2019 potential GDP as weights, of the individual countries rebalancing tax increases.[14] Table 1 shows this metric, together with two others: θ_τ^{AGK}, a similar metric but considers the tax increase is only imposed on future generations, and IBG, the intertemporal budget gap. Governments across the EA would need to increase taxes by 15 percent, for everyone and permanently. If instead they only put the burden on the generations born after 2019, then they would need to raise taxes by almost 30 percent.

Table 1: Imbalance Metrics

θ_τ	θ_τ^{AGK}	IBG
13.9%	29.9%	5.53

Note: The value of θ_τ reported corresponds to the weighted average of the rebalancing tax increase of each country computed according to Equation 7, weighted by the potential GDP of 2019 of each EA country. The other two metrics are also weighted averages of the country-specific metrics, using the 2019 potential GDP as weights and they are described in Appendix C.2.

We now examine the contributions to the overall balance by different age and country of birth groups.[15] Panel (a) of Figure 4 shows, for selected years, the decomposition of the primary balance by age group. As the dependency ratio rises, the negative contribution of the elderly population becomes larger, increasing from around 10 percent of GDP in 2019 to almost 20 percent of GDP in 2100. The young generations' negative contribution is relatively stable throughout the projection time, with a slight increase in the later years. Similarly, the positive contribution from the adult population is close to 18 percent in 2020 and remains stable for most of the projection.

Panel (b) of Figure 4 decomposes the projected primary balance by country of birth. The negative net contribution from EU-born citizens and their descendants is projected to widen. Furthermore, while the immigrant group initially has a positive net contribution, after 2060, it also becomes a net receiver. This is due to the life-cycle effects that also occur in this case: when these individuals immigrate, they are mostly at working age and hence are contributing positively to the government budget. Eventually, they will also retire, becoming net receivers. As a whole, the immigrant group is also aging, which is not compensated by the relatively younger new immigration flow, nor by the return migration of non-EU-born individuals at older ages.

Throughout the projection horizon, the descendants of immigrants have a negative contribution. This negative contribution comes from the age composition and the life-cycle net contribution pattern of this subpopulation.[16] In the first years of the projection, they are mostly benefiting from the education services provided by the government and hence have a negative contribution. This negative contribution decreases as they start entering the labor market but never reaches a positive

[14] If we aggregate the countries' budgets into a common EA budget the rebalancing tax increase would be 15%.
[15] For completeness, in Appendix F we show the decomposition of the primary balance by gender and skill level.
[16] We assume that the skill composition of the descendants of both natives and immigrants is the same.

value. In the later years of the projection, it increases as the older members of this group start to enter into retirement ages. This sets the baseline scenario of what aging would imply for public finances. Next, we analyze the extent to which migration can help solve the fiscal burden that aging creates.

5.2 The Nonlinear Effects of Migration on Public Finances

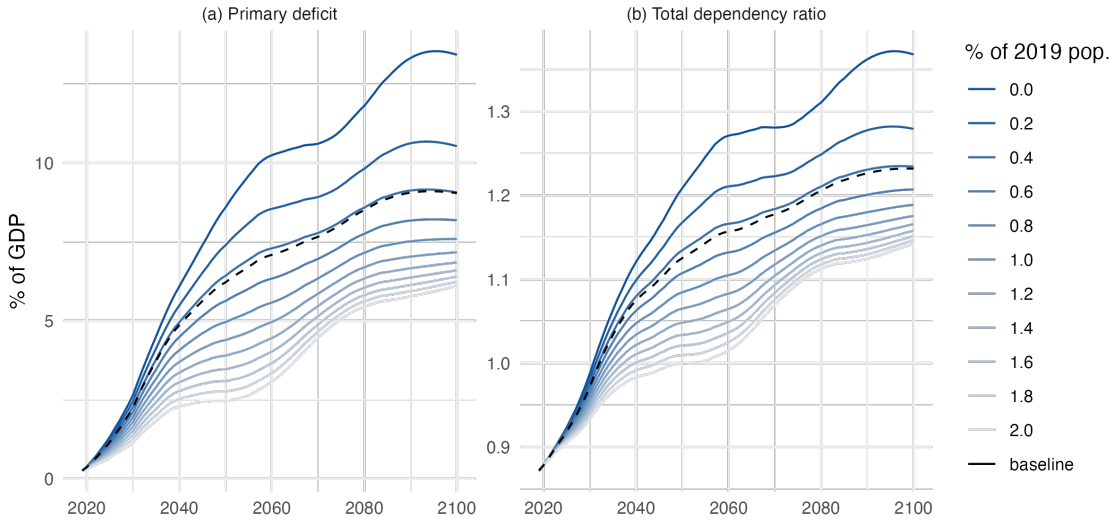
Migrants from outside the EU currently have a positive contribution to the budget. In our baseline projection, this contribution turns negative, as they are subject to the same aging trends as natives. This decomposition does not, however, speak to the effect that the size of migration flows has on fiscal aggregates. We turn to this issue in this subsection by running different population projections with different net migration flow sizes.

Our baseline projection assumes a constant net migration flow from non-EU countries each year at the level observed in 2019, which constitutes around 0.4 percent of the 2019 EA population. We now explore various demographic scenarios in all equal to the baseline, except in the net migration flow level. Specifically, we set for all countries of the EA the same fraction of non-EU net migration in the 2019 total population.. These transformations do not modify the age/gender/skill distribution of migration, only the total size of the net migration flow.[17] This exercise is equivalent to what we do in the stylized demographic model of Appendix B, where we simulate the demographic transition for different constant migration flows.

We start by looking at the primary government budget balance under the different migration scenarios. The left panel of Figure 5 plots the counterfactual path of the primary deficit in these different scenarios. Regardless of the migration level, the current small primary deficit is anticipated to increase and stabilize around the year 2080. Our results show that migration and public finance performance have a positive relation. A reduction in migration leads to a larger primary deficit, while an increase results in smaller deficits. This result aligns with other studies showing that immigration cannot fully solve the public finance sustainability issue faced by developed economies (Preston, 2014).

[17] This net migration flow includes the return migration, that is, the population returning to their origin countries.

Figure 5: Primary Balance and the Age-Dependency Ratio under Different Net Migration Scenarios

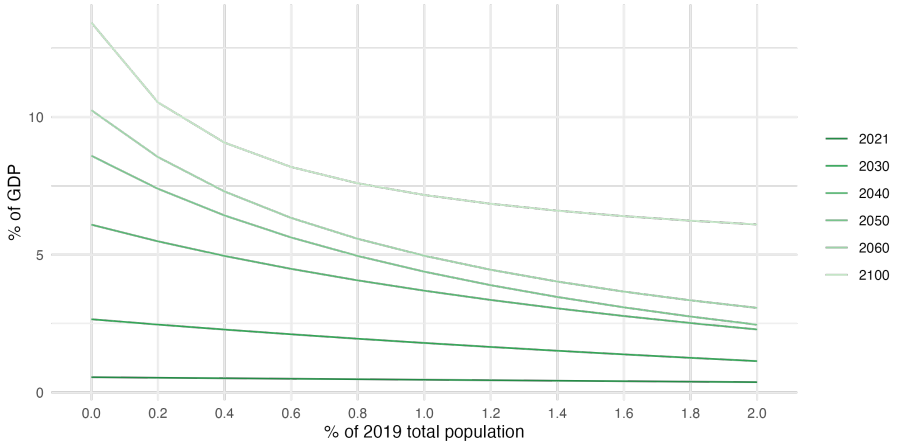


Note: Panel (a) shows the projected primary balance deficit as a percentage of the potential GDP for the different net migration scenarios. Panel (b) plots the total age-dependency ratio (computed as the sum of the young and the old populations divided by the working-age population) for these same net migration scenarios.

Notably, the relationship between migration size and the primary deficit is not linear. Instead, there is a uniform convergence pattern of the primary deficit as the net migration flows into Europe increase. Conversely, constraining migration has an increasing effect on the primary deficit; that is, reducing the net migration is linked to growing costs for public finances. This observed pattern is connected to the dynamics of the dependency ratio in the population projections, as evident in the comparison of both panels in Figure 5. Young and old individuals, as Figure 2 shows, are net receivers of the government budget, whereas working-age individuals are net contributors to the budget. With the projected trends of aging the relative size of the net contributors in the population decreases, which brings the increasing trend on the projected primary deficit.

Figure 6 illustrates the non-linear connection between the net migration flow level and the primary balance for selected years. The figure reveals a convex relationship, implying a diminishing impact of migration on the primary deficit, or conversely, increasing costs for public finances balance with migration restriction. These dynamics in the primary deficit come from the dynamics in the dependency ratio, as shown before. In fact, they are well-known by demographers. Schmertmann (1992) provides a summary of the implications of a constant migration flow in a population with a below-replacement fertility rate.

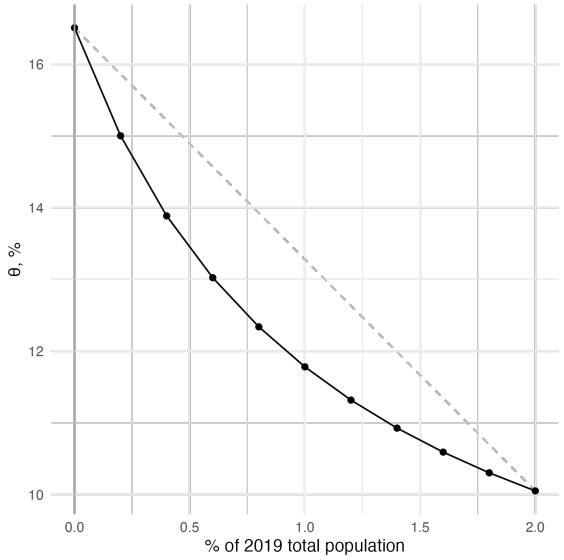
Figure 6: Primary Deficit under Different Net Migration Scenarios



Note: Panel (a) shows the projected primary balance deficit as a percentage of the potential GDP for the different net migration scenarios. Panel (b) plots the total age-dependency ratio (computed as the sum of the young and the old populations divided by the working-age population) for these same migration scenarios.

Given the different paths for the primary balance implied by the different net migration scenarios, let us now compute the corresponding rebalancing tax increase measure, θ_τ, to each scenario. Figure 7 draws the frontier between the the net migration flow and θ_τ. Consistent with the patterns in the primary balance projection, the tax adjustment necessary to restore sustainability increases if migration flows are reduced. The difference is substantial: if net migration from non-EU countries is zero, the rebalancing tax increase widens by a quarter, from 13.8 to 16.5 percent. Without immigrants coming in, the fiscal burden of aging becomes far heavier. For comparison, the metric θ_τ^{AGK}, without migration flows, would rise from 29.9 to 46.3 percent.

Figure 7: Frontier between the Level of Net Migration and the Rebalancing Tax Increase Implied, θ_τ



Note: The figure shows the weighted average θ_τ across countries using the 2019 potential GDP as weights, for the different net migration scenarios. The dashed line is an auxiliary straight line connecting the two extremes.

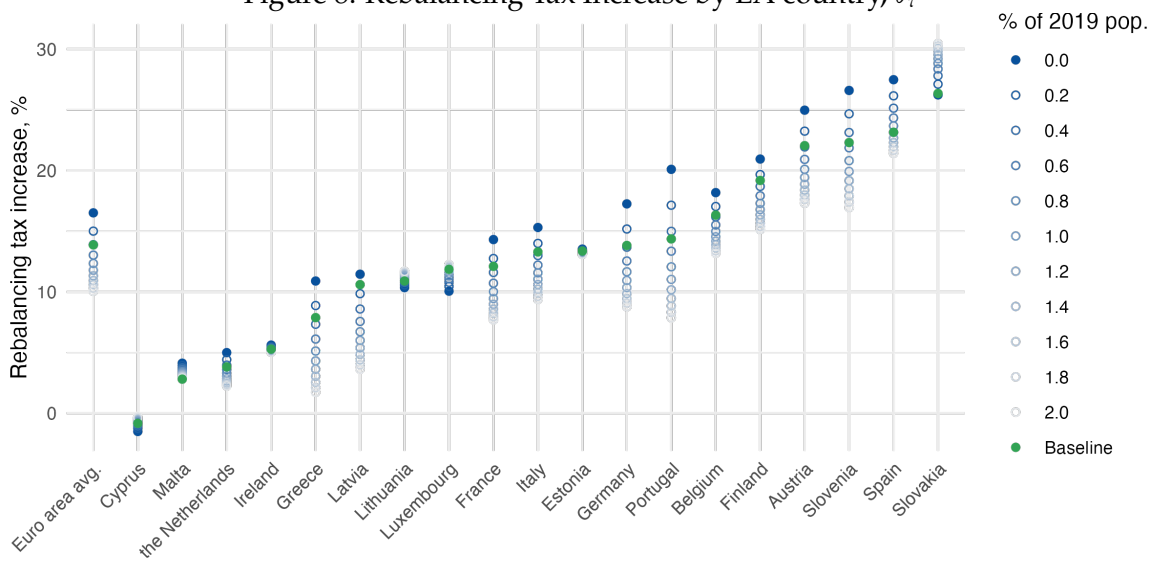
Moreover, as the plot clearly shows, the relationship between immigration and the fiscal burden of aging is not linear but rather convex. Each marginal reduction of the net migration flow has an increasing cost for public finances. In the case of the EA, this convexity matters quantitatively. Notice that if, hypothetically, immigration flows doubled in size, the rebalancing tax adjustment would decrease by only 1.5 percentage points. These gains are smaller, by about half than the costs of shutting down migration, meaning immigration cannot per se eliminate the fiscal burden of aging. In this sense, there are diminishing returns to increasing immigration on public finances. Nevertheless, even at the current level of immigration, Europe has not reached a point where it experiences no benefits from immigration in terms of public finances.

This convexity comes as a direct consequence of demographic dynamics presented in the stylized demographic model in Appendix B. In that model, this convexity emerges in the effects of immigration flows on the dependency ratio during the transition. We have shown that this carries through to a full, detailed demographic model, with information on the age, gender, and skill profiles of immigrants, and maps into the budget deficit using the demographic profiles of taxes and benefits in the data. To the best of our knowledge, this is a new result in the literature measuring the effects of immigration on public finances in developed countries.

Rebalancing tax increases at the country level All the results reported are at the EA level, which provides a summary of the situation at the European level. The average rebalancing tax increase provides a summary of the situation at the European level, which is very heterogeneous across countries. Although the dependency ratio has been increasing in all EA countries and is projected to continue to do so, there are substantial differences within the EA. Spain has a dependency ratio of 0.52 dependents per working-age person, whereas France has a dependency ratio of 0.64. The demographic trends are also heterogeneous, with countries projected to have higher fertility rates than others.

With these different aging trends, the sustainability of the public finance situation is also quite heterogeneous. In Figure 8, we report the country-specific rebalancing tax increase under different net migration scenarios. The baseline θ_τ corresponds to the rebalancing tax increase under the observed 2019 net migration scenario, allowing us to see which countries face a heavier fiscal burden of aging. Slovakia and Spain have the most unbalanced public finance situation and would need a permanent increase in taxes of 24 percent and 26 percent, respectively. On the other hand, Cyprus and the Netherlands are among the countries with the smallest rebalancing tax increase metric.

Figure 8: Rebalancing Tax Increase by EA country, θ_τ



Note: The figure shows the rebalancing tax increase, θ_τ, for the different countries of the EA, and for different scenarios of net migration.

Figure 8, also reports the country-specific rebalancing tax increase under different net migration scenarios. By comparing them with the baseline, we can see to which countries migration flows are (or can be) more important. Portugal is the country where setting the net migration flow to zero creates the largest difference in comparison with the baseline. The rebalancing tax increase would rise more than 5 percentage points. For other countries the impact of migration is smaller. The spread of the blue points in the figure allows to understand the costs and benefits that changing the net migration flow has in the sustainability of public finances. This impact is mostly related with the age and skill distribution of net migration in each country and the point in the frontier between the size of the flow and θ_τ that the country is in the baseline (closer, or further away from a flat area of the frontier).

One of the contributions of our paper is providing and applying a common methodology to measure the fiscal imbalances brought by aging and the role that migration can have in minimizing to different countries. Given the amount of data necessary to do this exercise and the different hypothesis that the methodology needs, there are not many papers that offer reasonable comparisons across countries.[18]

5.3 Robustness exercises

Interest rate and productivity growth rate In our baseline exercise, we set the demographic profiles growth rate, γ, the nominal interest rate, i, and the inflation rate, π, to the historical average of these variables between 1995 and 2021 i.e. 0.7%, 3.8%, and 1.68%, respectively. This implies a discount factor, D, equals 0.986. Our result of increasing costs of reducing migration flows to

[18] An exception to this is Berti et al. (2019).

public finance sustainability does not depend on the discounting effect. In fact, the rebalancing tax increase metric changes very little when we choose other values for D. One can see that by solving equation (7) to θ_τ. It yields a ratio between expenditures and debt, and revenues. As the value of the debt is much smaller in comparison with the size of the present discounted value of the stream of revenues and expenditures, changing D, increases both the numerator and the denominator essentially in the same proportion. In Appendix E.1, we compute θ_τ and plot the frontier between the level of migration and the imbalance factor, for different values of D.

Fertility rate of immigrants In our baseline scenario and in the different migration levels examined in the previous section, we take the fertility rate of the population born outside the EU in 2019 and assume a convergent path towards 2.1 children per woman by 2100. The choice for this path, arguably, could have an impact on the size of the immigrant population, and consequently on the fiscal benefits that migration brings. However, our results are robust to this hypothesis. Changing the fertility path only has a minor effect on the rebalancing tax increase metric value, and furthermore, does not change the convex relationship between migration and this metric. In Appendix E.2, we compute θ_τ for different assumptions of the fertility rate of the immigrants, as well as the frontier between the imbalance factor and the level of migration.

6 Conclusions

Many European countries have been experiencing an increase in political polarization, and migration policy has played a central role in that trend. Notably, immigration from developing countries has become a contentious issue. In this study, based on detailed data on taxes, benefits, and demographic dynamics, we revisited the question of how immigration can help relieve the fiscal burden of aging. Our analysis uncovers novel facts informing both policy discussions and future research on immigration and public finance.

Immigration has a positive, nonlinear effect on public finances. This indicates that restricting migration has increasing costs for public finances and, at the same time, that immigration alone cannot solve the fiscal burden of aging.

To arrive at this result, we first show, across the EA, that the current stock of migrants have a positive contribution to the government budget. Without them, the primary balance would be even more negative than it is nowadays. Other things equal, the projected demographic trends in Europe will bring the primary balance down to a large – and permanent – deficit within a few decades. With the same demographic profiles (by age, gender and education level) of the different budget items, sustainable public finances would require a permanent tax increase of 13.9 percent on average across the EA countries. The net migration flows embedded in our population projections play a significant role in this result: without them, the necessary rebalancing tax increase would be about 2.6 percentage points higher. Conversely, doubling the net migration inflows would only allow the permanent tax increase to be 1.5 percentage points lower.

By applying a common methodology to different European countries, this paper also provides a cross-country comparison of the impact of migration on public finances. These results are relevant for European policymakers considering restrictions on immigration from the developing world. Due to the beneficial effects of immigration on demographic dynamics, reducing immigration could significantly exacerbate the fiscal burden of aging.

References

Auerbach, A. J., J. Gokhale, and L. J. Kotlikoff (1991). Generational accounts: a meaningful alternative to deficit accounting. *Tax policy and the economy 5*, 55–110.

Auerbach, A. J. and P. Oreopoulos (1999). Analyzing the Fiscal Impact of U.S. Immigration. *American Economic Review 89*(2), 176–180.

Berti, K., A. Caretta, P. Eckefeldt, et al. (2019). The intergenerational dimension of fiscal sustainability. Technical report, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

Bonin, H., C. Patxot, and G. Souto (2014). Cyclically-Neutral Generational Accounting. *Fiscal Studies 35*(2), 117–137.

Chojnicki, X. and P. E. Rabesandratana (2018). Aging, Human Capital, and Productivity in France: A Generational Accounting Perspective. *Review of Income and Wealth 64*(4), 872–899.

Christl, M., A. Bélanger, A. Conte, J. Mazza, and E. Narazani (2022). Projecting the fiscal impact of immigration in the european union. *Fiscal Studies 43*(4), 365–385.

Coale, A. J. (1986). Demographic effects of below-replacement fertility and their social implications. *Population and Development Review 12*, 203–216.

Commission, E. (2018). The 2018 ageing report: Economic and budgetary projections for the eu member states. *Institutional Paper No. 79. Luxembourg: Publications Office of the European Union*.

Commission, E. (2021). The 2021 Ageing Report: Economic and Budgetary Projections for the EU Member States (2019-2070). Technical report, Institutional Paper No. 79. Luxembourg: Publications Office of the European Union (2018).

D'Albis, H., E. Boubtane, and D. Coulibaly (2019). Immigration and public finances in OECD countries. *Journal of Economic Dynamics and Control 99*, 116–151.

Dustmann, C. and T. Frattini (2014). The fiscal and welfare effects of immigration. *The Economic Journal 124*(580).

Espenshade, T. J., L. F. Bouvier, and W. B. Arthur (1982). Immigration and the stable population model. *Demography 19*(1), 125–133.

Eurostat (2020). Technical note: Summary methodology of the 2019-based population projections (europop2019).

Fehr, H., S. Jokisch, and L. J. Kotlikoff (2004). The Role of Immigration in Dealing with the Developed World's Demographic Transition. *FinanzArchiv 60*(3), 296.

Feist, K., B. raffelhuschenm, and R. Vanne (1999). Finland: macroeconomic turnabout and intergenerational redistribution. *Generational Accounting in Europe 6*.

Fiorio, C. V., T. Frattini, A. Riganti, and M. Christl (2023). Migration and public finances in the eu. *International Tax and Public Finance*, 1–50.

Franco, F., L. Teles Morais, and T. Bernardino (2020). The implications of ageing for public finances in Portugal. Technical report, Gulbenkian Foundation.

Furlanetto, F. and Ø. Robstad (2019). Immigration and the macroeconomy: Some new empirical evidence. *Review of Economic Dynamics 34*, 1–19.

Girouard, N. and C. André (2006). Measuring cyclically-adjusted budget balances for oecd countries. *Available at SSRN 2005002*.

Hansen, M. F., M. L. Schultz-Nielsen, and T. Tranæs (2017). The fiscal impact of immigration to welfare states of the Scandinavian type. *Journal of Population Economics 30*(3), 925–952.

Lee, R. and T. Miller (2000). Immigration, Social Security, and Broader Fiscal Impacts. *American Economic Review 90*(2), 350–354.

Mitra, S. (1990). Immigration, below-replacement fertility, and long-term national population trends. *Demography 27*, 121–129.

Motiejunaite-Schulmeister, A., A. Sicurella, and P. Birch (2022). The structure of the european education systems, 2022/2023. schematic diagrams. eurydice–facts and figures. *European Education and Culture Executive Agency, European Commission*.

Preston, I. (2014). The effect of immigration on public finances. *Economic Journal 124*(580), F569–F592.

Price, R., T.-T. Dang, and J. Botev (2015). Adjusting fiscal balances for the business cycle: New tax and expenditure elasticity estimates for oecd countries.

Rowthorn, R. (2008). The fiscal impact of immigration on the advanced economies. *Oxford Review of Economic Policy 24*(3), 560–580.

Schmertmann, C. P. (1992). Immigrantsâ ages and the structure of stationary populations with below-replacement fertility. *Demography 29*, 595–612.

Storesletten, K. (2000). Sustaining Fiscal Policy through Immigration. *Journal of Political Economy 108*(2), 300–323.

Storesletten, K. (2003). Fiscal implications of immigration - A net present value calculation. *Scandinavian Journal of Economics 105*(3), 487–506.

APPENDIX

A Macroeconomic framework

This section describes the macroeconomic model framework that is behind our accounting methodology.

We consider an endowment economy populated by overlapping generations of agents who differ across several demographic characteristics, including age, indexed by "demographic group" x. Each demographic group x, at each point in time t, comprises $P_{t,x}$ individuals. A fraction of them are working, whereas the remainder are either not yet working, or retired due to disability or old-age. Furthermore, each year, workers spend constant fractions of the time in three stages: employed, unemployed, or sick. There is also a government that collects taxes, manages social security and provides public services such as education and healthcare. Population dynamics are deterministic.

A.1 Endowment

A national trust fund receives a nominal endowment each year. This endowment grows deterministically from its initial value at $\bar{t}$, by growth rate γ plus price inflation rate π, as follows:

$$\Psi_t = \Psi_{\bar{t}} \prod_{j=\bar{t}+1}^{t} \left(1+\gamma_j\right)\left(1+\pi_j\right), \text{ for } t > \bar{t}. \tag{8}$$

The trust fund employs workers, and its ownership is scattered across the population. All of the endowment is distributed each year in the form of wages and dividends, governed, respectively, by a wage schedule $\{\varphi_x^l\}$, and a equity ownership structure $\{\varphi_x^k\}$, which may vary with demographics. Wages and dividends are paid out each period according to a constant capital share of income κ. Labor income is subject to a social security contribution rate, $\mathcal{T}^{SS}$, and dividend income subject to a corporate tax, $\mathcal{T}^K$. In this deterministic model economy, the endowment can be thought of as the GDP, so we will refer to it as such in the ensuing discussion.

A.2 Individuals

Income sources Individuals obtain income from wages and dividends, unemployment and sickness subsidies as well as disability, old-age and survivor pensions. When employed, workers receive a nominal wage, $y_{t,x}^l$, and when unemployed or sick, they receive the corresponding subsidy, $g_{t,x}^{unemp}$ or $g_{t,x}^{sick}$. Non-workers receive pensions $g_{t,x}^p$. Regardless of working status, individuals may receive dividend income, $y_{t,x}^k$. All of these sources of income are subject to income taxes at rates that may vary by demographic group, $\{\mathcal{T}_x^{PIT}\}$.

We can then summarize the total net income of an individual of group x as follows:

$$y_{t,x} = \begin{cases} \left(1 - \mathcal{T}_x^{PIT}\right)\left(y_{t,x}^l + y_{t,x}^k + g_{t,x}^{unemp} + g_{t,x}^{sick}\right), & \text{if working;} \\ \left(1 - \mathcal{T}_x^{PIT}\right) g_{t,x}^p, & \text{if not working.} \end{cases}$$

Housing and financial assets At 18 or on arrival for immigrants above 18, individuals are endowed with a house. They then invest in the house each year, according to a fixed life cycle plan. The aggregate house price index evolves 1-to-1 with GDP, and house qualities $\tilde{h}$ are normalized to 1 at the age of 18. So the property value of an individual of age a in year t is:

$$h_{t,x} = \tilde{h}_{a,\bar{x}} \bar{H} \Psi_t$$

where $\bar{H}$ gives the initial value of the house (as a percentage of GDP), and $\bar{x}$ designates demographic characteristics other than age. Each year, the government taxes properties at a constant rate $\mathcal{T}^H$.

In a similar fashion, individuals are endowed at each age with an equity stake in the trust fund, $k_{t,x}$. Further, individuals may also save in cash, $b_{t,x}^f$, which bears no return. There is no wealth tax on these financial asset.

Consumption and savings Individuals consume a fixed fraction c_x of their income, depending on demographics. Their consumption is subject to consumption tax at rate $\mathcal{T}^{VAT}$. Cash holdings are then determined as a residual of the change of equity holdings minus consumption:

$$\left(b_{t,a,\bar{x}}^f - b_{t-1,a-1,\bar{x}}^f\right) + \left(k_{t,a,\bar{x}} - k_{t-1,a-1,\bar{x}}\right) = y_{t,a,\bar{x}}\left(1 - c_x\right).$$

A.3 The government

The government collects the taxes and pays out social benefits, as mentioned above. Beyond that, it may further spend on education, healthcare and general public goods, and impose an additional lump sum tax on everyone.

Taxes Housing, consumption and corporate income are taxed at a constant rate, as previously discussed. Social security contributions are also a constant proportion of the wage. For personal income taxes, the government discriminates across demographic groups $\left\{\mathcal{T}_x^{IRS}\right\}$. Finally, there is a constant lump-sum tax, $\mathcal{T}^u$.

Government revenue in a year t, T_t, is the sum of the different sources of revenue described above, across demographic groups:

$$T_t = \sum_i T_t^i = \sum_{x \in X} \begin{bmatrix} \mathcal{T}_x^{IRS} \left(y_{t,x}^l + y_{t,x}^k + g_{t,x}^{unemp} + g_{t,x}^{sick} + g_{t,x}^p \right) \\ +\mathcal{T}^K y_{t,x}^k + \mathcal{T}^{VAT} y_{t,x}^l c_x \\ +\mathcal{T}^{SS} y_{t,x}^l + \mathcal{T}^H h_{t,x} + \mathcal{T}^u \end{bmatrix} P_{t,x} \tag{9}$$

Expenditure All cash benefits are indexed to the wages of the corresponding demographic group, so that for any type of benefit i, the per capita payment is given by

$$g_{t,x}^i = \Gamma^i y_{t,x}^l, \ i = \text{unemp, sick, p}$$

where Γ^i is a generosity scalar for that benefit.

Per capita government consumption is indexed to the GDP , and determined according to a fixed policy that discriminates across ages and gender. So for any type of spending i, per capita expenditure is given by

$$g_{t,x}^i = \Gamma_x^i \Psi_{\bar{t}} \Pi_t, \ i = \text{educ, health, PG}$$

where Γ_x^i define the age structure of the government policy for that benefit.

Government expenditure in a year t, G_t is the sum of all the different expenditure items, across demographic groups:

$$G_t = \sum_i G_t^i = \sum_{x \in X} \begin{bmatrix} g_{t,x}^{unemp} & +g_{t,x}^p & +g_{t,x}^{sick} \\ +g_{t,x}^{health} & +g_{t,x}^{educ} & +g_{t,x}^{PG} \end{bmatrix} P_{t,x} \tag{10}$$

Government budget constraint The government of country n faces a yearly nominal budget constraint, where government bonds at the end of a period are equal to the sum of the primary deficit with the government debt of the previous period plus interest paid on that debt:

$$B_t = G_t - T_t + (1 + i_t) B_{t-1}, \tag{11}$$

where B_t is government debt in period t and i_t is the implicit nominal interest rate paid on the debt during period t.

Additionally, the government faces an intertemporal budget constraint (IGBC):

$$\sum_{s=0}^{\infty} \prod_{j=1}^{s} \frac{T_{\bar{t}+s}}{\left(1 + i_{\bar{t}+j}\right)} = \sum_{s=0}^{\infty} \prod_{j=1}^{s} \frac{G_{\bar{t}+s}}{\left(1 + i_{\bar{t}+j}\right)} + B_{\bar{t}-1} \tag{12}$$

The IGBC imposes that the net present value of the public debt must be zero. This means that the

government's budget must be balanced, in a long-run perspective: it can incur in large deficits in the short run, but must offset them with surpluses later.

The question is then, how much must taxes increase for Equation (12) to hold, as in Section 2.

B A simple demographic model to understand the population dynamics

In this Appendix we build a simple stylized demographic model that explains the demographic result that the immigration size has a non-linear effect on the age-dependency ratio. This simple model allows us to trace out the same population dynamics that are present in the projections underlying our empirical exercise, but in a simplified structure that allows us to understand them better. We start by describing the model which is a stylized representation of the population dynamics. We then, describe some properties of the model steady-state. Finally, we show, with simulation, how migration affects the dependency ratio during the demographic transition.

B.1 Set-up

The model structure aims to capture the essential features present in current European population dynamics.

The population P is composed in each period of three generations, the young generation P_y, the adult generation P_a, and the old P_o. The adult generation is characterized by the ability to have children.

Immigrants enter the population as adults, capturing the feature of the data that most immigrants from outside the EU are of working ages.[19] The adult population is further split into P_a^F, foreign adult population, and P_a^N native adult population. There is an exogenous flow of immigrants, a constant absolute value M, in keeping with the most common assumption in demographic literature and indeed in official population projections.

The fertility of immigrants f^f may potentially differ from the fertility of natives f^N, as in the data. The offspring of immigrants enter the *native* young population.

The population stock of each group evolves over time t according to the following system of difference equations:

$$\begin{aligned} P_{o,t} &= (1-\pi_m)P_{o,t-1} + \pi_o\left(P^N_{a,t-1} + P^F_{a,t-1}\right) \\ P^N_{a,t} &= (1-\pi_o)P^N_{a,t-1} + \pi_a P_{y,t-1} \\ P^F_{a,t} &= (1-\pi_o)P^F_{a,t-1} + M \\ P_{y,t} &= (1-\pi_a)P_{y,t-1} + f^N P^N_{a,t-1} + f^F P^F_{a,t-1}. \end{aligned} \tag{13}$$

[19] Figure 1 illustrates this pattern.

Each period, the old face a certain probability π_m of death (mortality rate), adults (both foreign and native) enter retirement with a probability π_o, and young people enter adulthood with a probability π_a. The Markov chain structure allows us to capture the key features of the life cycle: a certain time spent in infancy before becoming fertile and productive; and aging, where after some time individuals are no longer fertile and productive, and enter a stage in which they face some likelihood of death. Evidently this model has some simplifying assumptions: no distinction between ages within groups, so for a given individual, the expected time spent in each age group will be counterfactual to the data; and non-old-people have zero likelihood of death. These assumptions do not influence any of the results we highlight here.

This stylized model captures all the main features of the demographic dynamics present in our empirical exercise and, in fact, in most demographic projections including official scenarios such as those produced by Eurostat.

B.2 Stable population results

We begin by highlighting in our framework some stable population results well known in the demography literature (Schmertmann, 1992 provides a summary of these results). When discussing results related to the age structure of the population, our focus will be on the total dependency ratio, which is defined as the ratio of the non-working age population (young and old) to the working age population (adults). This measure is particularly pertinent for fiscal considerations as it provides a good approximation of the ratio of net beneficiaries from the government budget per net contributor.

Stationary through immigration When native fertility rates are below replacement, this model gives rise to a long run solution characterized by a stationary population, with a fixed age structure and population size (i.e. a population growth rate of zero). This stationary population consists, in essence, of immigrants and their descendants. The size of the immigration flow will be important in determining the size of this stationary population, but not its age structure. If immigrants' fertility is higher than natives', this will affect the age structure of the stationary population, but not the overall conclusion, as long as immigrants' offspring reverts to native fertility.[20] We therefore start by focusing on the simplest case of $f^F = f^N \equiv f$ in the ensuing discussion. We then show that the results carry through to the case $f^F > f^N$.

This can be easily seen by casting the model in state space form:

$$\mathbf{P}_t = A\mathbf{P}_{t-1} + B. \tag{14}$$

where $\mathbf{P}_t = \begin{bmatrix} P_{o,t} & P_{a,t} & P_{y,t} \end{bmatrix}'$, $B = \begin{bmatrix} 0 & M & 0 \end{bmatrix}'$ and :

[20] In fact, Espenshade et al. (1982) show this is true as long as some n^{th} generation of immigrants' descendants reverts to native fertility.

$$A = \begin{bmatrix} 1-\pi_{-} & \pi_o & 0 \\ 0 & 1-\pi_o & \pi_a \\ 0 & f & 1-\pi_a \end{bmatrix}$$

All of the eigenvalues of A are inside the unit circle given our parameter definitions and in the case of fertility below replacement ($f < \pi_0$). This means $I - A$ is invertible so we can solve the model backwards, computing:

$$\mathbf{P}_t = A^t \mathbf{P}_0 + (I - A)^{-1}(I - A^t)B. \tag{15}$$

The stationary population is then given by

$$\lim_{t\to\infty} \mathbf{P}_t \equiv \mathbf{P} = (I - A)^{-1} B$$

$$\mathbf{P} = M \times \frac{1}{\pi_{\mathrm{o}} - \mathrm{f}} \times \begin{bmatrix} \frac{\pi_{\mathrm{o}}}{\pi_{\mathrm{m}}} \\ 1 \\ \frac{\mathrm{f}}{\pi_{\mathrm{a}}} \end{bmatrix}. \tag{16}$$

The above equation makes it clear that the size of the immigration flow only matters for determining the scale of the stationary population, and not its age structure.[21] In the stationary population, the total dependency ratio is given directly by $\frac{f}{\pi_a} + \frac{\pi_o}{\pi_m}$, which does not depend on M, although it depends on other parameters. In fact, the dependency ratio increases in f (there will be a higher share of children) and in π_o, as the ratio of time spent in old-age to adulthood increases, increasing the share of old. It decreases in π_m – higher mortality means lower life expectancy and time spent in old-age, reducing the share of old – and in π_a, as children becoming adults faster means a lower share of young.

Population dynamics of this kind are often called "stationary through immigration" or "SI" in the demography literature. All population projections for advanced economies incur in these kind of dynamics. The demographic dynamics that we have in our empirical section are no exception.

Extinction without immigration Without immigration (i.e. $M = 0$), there is still a stable population, with constant population growth and a fixed age structure. However, in this case, as native fertility rates are below replacement, in the long run total population becomes zero, or, in demographic terms, faces extinction.[22] In this model, this stable population is characterized by a negative growth rate given by the largest eigenvalue of A. (Coale, 1986) The dependency ratio

[21] Mitra (1990) shows how the age structure of immigrants impacts the structure of stationary populations.

[22] In the demographics literature, typically SI populations are compared against the corresponding replacement-fertility stationary population, i.e. with the same mortality rates but higher fertility such that a zero growth rate is achieved.

becomes a more complicated combination of parameters, which we numerically show next that, under a realistic calibration, gives a higher value than in the case.

Stationary through immigration population with higher immigrant fertility In the case $f^N < f^f$, the model no longer collapses into a 3-equation structure so in the state space representation we have:

$$\mathbf{P}_t = A\mathbf{P}_{t-1} + B. \tag{17}$$

where $\mathbf{P}_t = \begin{bmatrix} P_{o,t} & P^N_{a,t} & P^F_{a,t} & P_{y,t} \end{bmatrix}'$, $B = \begin{bmatrix} 0 & 0 & M & 0 \end{bmatrix}'$ and :

$$A = \begin{bmatrix} 1-\pi_- & \pi_o & \pi_o & 0 \\ 0 & 1-\pi_o & 0 & \pi_a \\ 0 & 0 & 1-\pi_o & 0 \\ 0 & f^N & f^F & 1-\pi_a \end{bmatrix}$$

All of the eigenvalues of A are inside the unit circle given our parameter definitions and in the case of fertility below replacement ($f < \pi_0$), as in the $f^N = f^f$ case, the difference being that f^N appears in place of f:

$$\begin{bmatrix} 1-\pi_m & 0 & 0 & 0 \\ 0 & 1-\pi_o & 0 & 0 \\ 0 & 0 & -\frac{\pi_a}{2} - \frac{\pi_o}{2} - \frac{\sqrt{4f^N\pi_a + \pi_a^2 - 2\pi_a\pi_o + \pi_o^2}}{2} + 1 & 0 \\ 0 & 0 & 0 & -\frac{\pi_a}{2} - \frac{\pi_o}{2} + \frac{\sqrt{4f^N\pi_a + \pi_a^2 - 2\pi_a\pi_o + \pi_o^2}}{2} + 1 \end{bmatrix}$$

And the stationary population is given by:

$$\begin{aligned} \mathbf{P} &= (I - A)^{-1}B \\ \mathbf{P} &= M \times \begin{bmatrix} \frac{1}{\pi_o - f_N} \times \frac{\pi_o + f_F - f_N}{\pi_m} \\ \frac{1}{\pi_o - f_N} \times \frac{f_F}{\pi_o} \\ \frac{1}{\pi_o} \\ \frac{1}{\pi_o - f_N} \times \frac{f_F}{\pi_a} \end{bmatrix} \end{aligned} \tag{18}$$

The above equation makes it clear that the size of the immigration flow only matters for determining the scale of the stationary population, and not its age structure. In the stationary population, the total dependency ratio is now given by:

$$\frac{\pi_a\pi_m\left(f_F - f_N + \pi_o\right)}{\pi_o\left(f_F\pi_m + \pi_a\left(f_F - f_N + \pi_o\right)\right)}$$

which collapses to the same dependency ratio as discussed in the main text, if $f_F = f_N$. It still does not depend on M. Again the size of the immigration flow only matters for determining the scale of the stationary population, and not its age structure.

B.3 Transitional dynamics

Given any initial population, with positive migration inflows the model's long run solution will be given by equation (16), the first case above. If M is set to zero, we are instead at the second case. Importantly for our purposes, there is one single long run dependency ratio for any $M > 0$, and another, higher, in the case of $M = 0$.

In the transition to those long run solutions from some initial population, matters are different. In particular, the relevant case considering the data in most European countries is marked by an initial dependency ratio markedly lower than the corresponding stationary solution (an aging population). In this case, we will observe that as $M \to 0$, the dependency ratio in the transition becomes closer to the path associated with the extinction case, and takes many periods to latch on to a different path taking it to the stationary SI solution. For higher values of M, the transition path is, from the outset, clearly different and associated with its final stationary state.

We provide an example of this by simulating the model above. The calibration does not intend to reproduce any specific country but reflects the facts, observed in most European countries, that the fertility rate of the native adults is below replacement, while that of the foreign adults is above.[23] We set the initial values of the age group shares to match the shares observed in the EA in 2021, such that the initial dependency ratio is 57%.

We examine the transition of the dependency ratio under different values for the size of the immigration flow, between 0 and 10% of the initial population (0, 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10%). Figure 9 plots the value of the dependency ratio along the transition for the different scenarios.

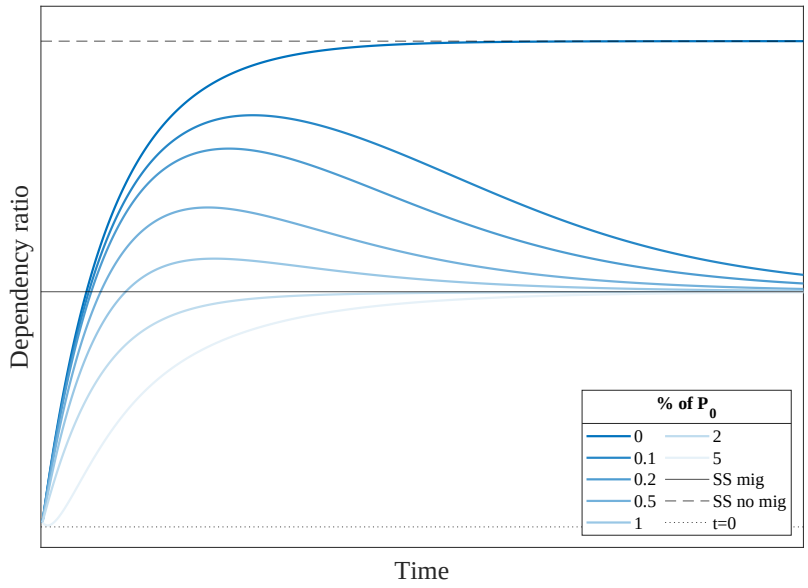
The model simulation produces an age distribution throughout the transition, demonstrating a convergence pattern to the stationary dependency ratio value of 1.17 for all positive values of immigration. However, this value is only attained after several hundred periods. This illustrates that the size of the immigration flow has no impact on the age structure of the SI, as shown before.

Nevertheless, immigration does impact the age distribution during the demographic transition toward the stationary population. A smaller immigration flow leads to higher dependency ratios. As the dependency ratio serves as a concise representation of the fiscal burden of aging, higher ratios are associated with increased deficits, indicating a larger fiscal burden of aging. This aligns with established findings that immigration can alleviate long-term fiscal imbalances, as demonstrated by studies like Lee and Miller (2000).

In the absence of migration, the dependency ratio converges to a higher value. However, with any positive value of immigration, the steady-state dependency ratio remains unchanged. As the size

[23] This is the pattern observed in the most recent data for Europe.

Figure 9: Total Dependency Ratio Along the Demographic Transition



Note: The total dependency ratio is the quotient between the young and old population over the adult population. This Figure plots this ratio for different scenarios of an immigration reduction along the first 500 periods of the demographic transition to the steady-state.

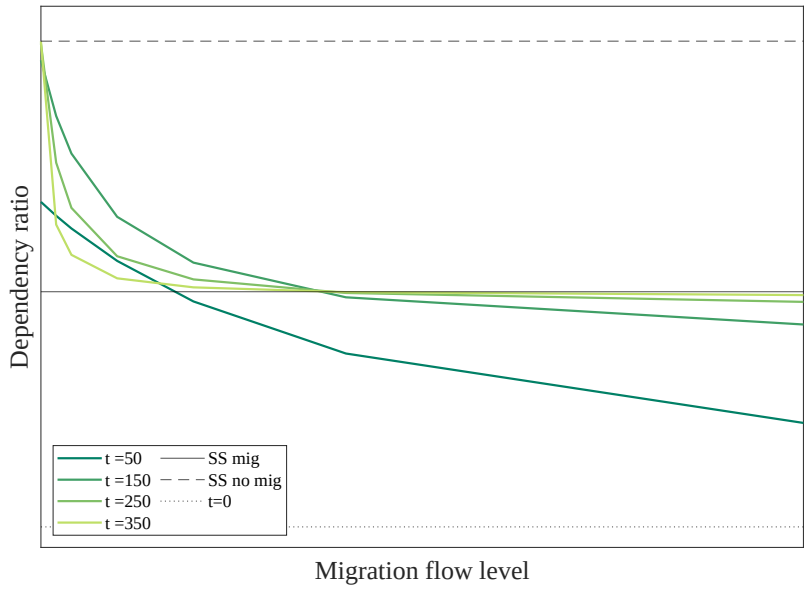
of immigration approaches zero from below, the dependency ratio follows a transition path closer to the convergence path observed in the no-migration scenario but does so for an extended period.

Furthermore, there exists a non-linear relationship between the immigration flow and the dependency ratio throughout the transition. Increasing the immigration flow reduces the dependency ratio, but the reductions diminish as the flow size increases for any period during the transition. This implies that, starting from a baseline, the increase in immigration has a diminishing effect on reducing the dependency ratio, whereas decreasing the immigration flow results in an increasing effect on the ratio.

To illustrate this, we depict in Figure 10 the connection between migration flow levels and the dependency ratio for three specific years during the transition. The Figure reveals the convex relation, implying a diminishing impact of immigration on the dependency ratio, or conversely, increasing costs for the dependency ratio with immigration restrictions throughout the transition. Additionally, the Figure indicates that over later periods of time, immigration flow exerts a smaller influence, evident in the flattening of the relationship for higher immigration levels.

In summary, our simple demographic model has two implications for the impact of the immigration flow on the population age distribution. First, the size of immigration flow does not have an impact on the stationary population age distribution, except in the knife-edge case of zero migration. Second, a smaller level of immigration worsens the dependency ratio along the transition, but at an increasing rate. With these conclusions in mind, we explore in the main part of the paper the

Figure 10: Total Dependency Ratio and Migration Flow for Selected Years of the Transition



Note: The total dependency ratio is the quotient between the young and old population over the adult population. This Figure plots this ratio for different scenarios on selected years of the demographic transition.

role of immigration in closing the aging gap in Europe. In that empirical exercise, we will utilize full population projections by age, gender, education and country of birth. Still, the main results depend on the same dynamic forces that we have illustrated in the simple model above.

C Methodological details

C.1 Cyclical-neutral fiscal aggregates

Our methodology implies choosing a base year, $\bar{t}$, from which the demographic and macroeconomic assumptions operate in order to project the demographic profiles of the different budget items and, finally, compute the different imbalance metrics. Therefore, the results depend on this choice as, when we project from $\bar{t}$ onward, we are implicitly carrying the business cycle position of the base year. In order to clean the long-term projections from the initial business-cycle position, the literature has been using different solutions.

A first approach is choosing a base year where GDP is close to the potential GDP. This approach is used by Franco et al. (2020) where we pick 2017 as a base year which, according to the AMECO database, is the year in the last decade where the output gap was closer to 0. A second approach that is used by Feist et al. (1999) consists in departing from the most contemporaneous period and making *ad hoc* adjustments along the projection to what is considered a cyclically-neutral state. In this paper, we use a third approach that computes cyclical-neutral fiscal aggregates and projects

from them toward the future.

The idea is to compute the budget item's level that would be observed if the economy in period $\bar{t}$ was at full employment and carry those values on the subsequent steps of the methodology. This way, we obtain cyclically neutral generational accounts, an innovation in the GA methodology first introduced in Bonin et al. (2014) based on the work by Girouard and André (2006). In order to compute, the cyclically neutral revenue item i as $\left(T^i_{\bar{t}}\right)^*$ consider the following relationship:

$$\frac{\left(T^i_{\bar{t}}\right)^*}{T^i_{\bar{t}}} = \left(\frac{Y^*_{\bar{t}}}{Y_{\bar{t}}}\right)^{\varepsilon_{i,Y}},$$

where $T^i_{\bar{t}}$ is the observed value of the revenue item i in the base year, $Y^*_{\bar{t}}$ is the potential GDP of the year $\bar{t}$, $Y_{\bar{t}}$ is the observed value of GDP in year $\bar{t}$ and $\varepsilon_{i,Y}$ is the elasticity of revenue category i with respect to the output gap. We compute the cyclically adjusted value of 4 out of the 5 revenue budget items: PIT, CIT, VAT, and SS contributions. For the expenditure items we only consider the unemployment benefits item, which observes the same relationship, *mutatis mutandis*. In Table 3 we describe the sources of the elasticities numbers that we use, as well as the source of the potential GDP.

C.2 Other metrics for comparison

While θ_τ is our preferred metric in order to the intertemporal government budget constraint (IGBC) holds, for comparability with other studies that use the generational accounting methodology, we compute two additional metrics used in this literature. In this Appendix, we provide the formulas using our notation.

1. The AGK imbalance factor: developed in the seminal paper of this methodology, Auerbach et al. (1991), it corresponds to the percentage difference in net tax payments of future generations (those born after the base year) and the net tax payments of current generations. It can be interpreted as how much the government would need to increase taxes to the future generations in order to the IGBC hold. It is given by

$$\theta^{AGK}_{\tau} = \frac{\sum_{s=0}^{J}\sum_{n\in EA}\sum_{i}\sum_{a=s}^{J}\sum_{g,k,c} D^s\left(g^i_{\bar{t},n,a,g,k,c} - \tau^i_{\bar{t},n,a,g,k,c}\right)P_{\bar{t}+s,n,a,g,k,c} + \sum_{s=1}^{\infty}\sum_{n\in EA}\sum_{i}\sum_{a=0}^{min\{s,J\}}\sum_{g,k,c} D^s g^i_{\bar{t},a,n,g,k,c}P_{\bar{t}+s,n,a,g,k,c} + B_{\bar{t}-1,EA}}{\sum_{s=1}^{\infty}\sum_{n\in EA}\sum_{i}\sum_{a=0}^{min\{s,J\}}\sum_{g,k,c} D^s\tau^i_{\bar{t},n,a,g,k,c}P_{\bar{t}+s,n,a,g,k,c}} - 1.$$

2. The IBG metric: it is the simplest way of measuring imbalances and it corresponds to the discounted sum of future deficits plus current government debt divided by the current GDP. It can be seen as the "future public debt" in case the demographic structure of the budget remains the same. It is given by:

$$IBG = \frac{\sum_{s=0}^{\infty}\sum_{n\in EA}\sum_{i}\sum_{x\in X} D^s\left(g^i_{\bar{t},n,x} - \tau^i_{\bar{t},x}\right)P_{\bar{t}+s,n,x} + B_{\bar{t}-1,EA}}{Y_{\bar{t}}}.$$

C.3 Estimation of the age, gender, skill and country of birth profiles

Taxes and social benefits Estimating the demographic profiles of each age-mappable budget item requires individual-level data, which we obtained in most cases. However, four of the tax items we use are paid at the household level. In these cases, allocating the tax burden to different demographic groups requires assumptions on how it is shared within the households. We do so by allocating taxes to household members in two ways: i) in proportion to the share of the total household income they earn (personal income and value-added taxes); ii) uniformly (property and corporate income tax).

After this step, we derive sub-samples by demographic group. Recall that a demographic group x is the cartesian product of age, a, gender, g, skill-level, k, and country of birth, c. Due to sample size limitation and in order to increase the precision of our estimates, we consider age groups of 5 ages, two gender groups (males and females), and three levels of skill: low, medium, and high, defined based on the education attained as explained in section 3. For some budget items, we do not consider gender and/or skill heterogeneity. Where the difference between male and female sub-samples is statistically insignificant, we do not split on gender, and similarly for the skill-level, in order to get more precise estimates. Table 2 in Appendix D.1 describes these aggregation choices for each budget item.

We do not split the microdata by birthplace group. The reason is that the percentage of immigrants in some countries is so small, that in the data there are not enough observations along the other dimensions, namely age. By combining our detailed population data with skill heterogeneity in the tax-benefit profiles, differences between immigrants and natives are solely based on their different skill compositions. In our data, the EU-born are more educated than the non-EU-born immigrants.

Finally, we obtain demographic profiles for each tax or benefit and for each country by computing mean estimates for each sub-sample, taking into account complex survey design (survey weights and multiple imputations).

Education and healthcare We derive an age profile of education spending based on Eurostat data that has the government spending by level of studies. We allocate the spending to the expected age that an individual attends each level of study according to the report by Motiejunaite-Schulmeister et al. (2022). We do not consider any heterogeneity in terms of gender, skill, or country of birth.

Healthcare age-gender profiles are obtained directly from the data made available by the European Commission (2021).

Proportional adjustment to match national accounts The last step is to adjust the estimated profiles, using a proportionality rule, to match national accounts aggregates for the different budget components of interest. This allows our projection exercise to be consistent with the aggregate budget balance. Note this is not only necessary in those cases where we use the distribution of proxy variables to map taxes and benefits to demographic groups (e.g. household private equity

holdings for mapping corporate income tax). This step is also necessary for variables that can be directly mapped in survey data, because the survey aggregate estimates are typically not consistent with the national accounts aggregates, either due to timing or to limitations of the survey data.

C.4 Building population projections

For the most part, we take inputs from EUROPOP2019 (such as mortality or fertility rates by age) and combine these with additional data and assumptions to build customized demographic projections for the population of each country by age, gender, skill, and birthplace for 2019-2100.

Fertility and mortality The mortality rate used is the same across skill-level and country of birth and only differs by age and gender.[24] We abstract from differences that could imply different life expectancy and mortality rates between EU-born and non-EU-born, or educational backgrounds.

Regarding fertility rates, we take data on live births by age and country of birth of the mother for the base year, 2019. Then, for the EU-born group, we use the growth of the fertility rate assumed in the EUROPOP2019 projections. This leads to an increasing linear convergence path, achieving 1.6 in 2100. For the other two country of birth groups, different assumptions are required. For the non-EU-born group, we assume that it has a decreasing linear convergence path toward 2.1 by 2100. These fertility rates apply both to immigrants and their offspring.

Net migration and country of birth Net migration is set to be constant and equal to the 2019 values and age distribution in the baseline. For each age and gender, these are split by country of birth group according to the shares observed in 2019. We do the same for emigrants and then compute the net migration as the difference between both. In the robustness subsection, we explore alternative assumptions for total net migration flows.

Skill/Education We further split the population by skill-level. Data on skill and country of birth compositions by age group is available for 2019. Then, for the projections, we construct a future path for the skill distribution using the skill shares observed by country of birth for the cohort aged 25 in 2019. This further relies on some simplifying assumptions: (i) for each individual, skill does not fall or increase along the life cycle beyond age 25; (ii) all education paths are complete by that age; (iii) immigrants' offspring have the same skill distribution as the natives.

These assumptions imply that, during the projection period, the skill distribution converges to a stationary distribution. In that stationary state, the low-skilled group share in the adult population is smaller than in the base period and, conversely, the medium and high-skill adult population share is higher. Our skill distribution projection can be seen as a pessimistic scenario since most

[24] It corresponds to the mortality projected for each country in the central projection of EUROPOP2019 by age and gender with a small modification at the age of 100, where we set the survival probability to 0.

peripheral EU countries observe an increasing skill-level. Because it is out of the scope of this paper to analyze the impact of different skill distributions for public finances, we stick with our conservative projection on the skill-level evolution. Furthermore, significant changes to the skill distribution have implications for productivity growth, with second-order effects on taxes and benefits possibly requiring a general equilibrium analysis.

D Additional data sources details

D.1 Micro-data sources

Table 2: Microdata Sources

Fiscal Category	Source	Observations
PIT	EU-SILC	-
Property tax	EU-SILC	No gender heterogeneity
VAT	HBS	The last wave was produced in 2015
CIT	HFCS - wave 3	No gender heterogeneity
Social Contributions	EU-SILC	-
Disability pension	EU-SILC	-
Old-age pension	EU-SILC	-
Sickness allowance	EU-SILC	No skill heterogeneity
Survivor pension	EU-SILC	No skill heterogeneity
Unemployment subsidy	EU-SILC	No skill or gender heterogeneity
Education expenditure	Eurostat	No skill or gender heterogeneity
Health expenditure	AWG 2019 (EU average)	No skill heterogeneity

D.2 Macro-data sources

Table 3: Macrodata Sources

Aggregate	Variable	Observations
Demographic data (from Eurostat)		
Historical population	demo_pjan	
Population projections	proj_19n	
Fiscal data (from Eurostat - gov_10a_ggfa data-set)		
Personal income	D51A	Split according to the public accounting
Property	D29A	
Value-added	D211	
Corporate income	D51B	
SS contributions	D611+D612+ D613	
Disability pension	GF1001	
Sickness allowance	GF1001	
Old-age pension	GF1002	
Survivor pension	GF1003	
Unemployment subsidy	GF1005	
Education expenditure	GF09	Capital expenditure is uniformly distributed.
Health expenditure	GF07	Capital expenditure is uniformly distributed.
Other macro variables		
GDP	Eurostat: CP_MEUR	
Potential GDP	AMECO: OVGDP	
Elasticities budget items	From Price et al. (2015)	
GDP deflator	Eurostat: PD15_EUR	
Net wealth	Eurostat: gov_10a	

E Robustness tests

E.1 Macroeconomic hypothesis

Our methodology implies hypothesizing about the interest rate, i, and the productivity growth rate, γ. In order for the present discounted value of revenues and expenditures to be a finite number, we must have these parameters such that $D \in (-1, 1)$. Otherwise, the intertemporal budget constraint loses its meaning and the exercise becomes inconsistent. Within these bounds, we perform a sensitivity analysis under two different extreme scenarios: the first with the demographic profiles not growing in real terms, and the second the knife-edge case where the profiles growth rate is almost equal to the interest rate.[25] Table 4 shows the imbalance metrics for these two different scenarios. The θ_τ imbalance factor changes very little to different macroeconomic assumptions. Furthermore, we see that our preferred metric has an advantage over the other two, due to its non-sensitivity to the macroeconomic assumptions. The discount factor affects both the revenues and the expenditure, and hence the effects on θ_τ are very small – they are not zero because of the public debt value.

Table 4: Imbalance Metrics under Different Macroeconomic Assumptions

Scenario	θ_τ	θ_τ^{AKG}	IBG
Baseline	15.0%	29.9%	5.53
$\gamma = 0$	14.5%	35.9%	3.80
$\gamma = r$	16.1%	22.9%	14.91

Note: θ_τ is computed according to equation (7). The other two metrics are described in the Appendix C.2.

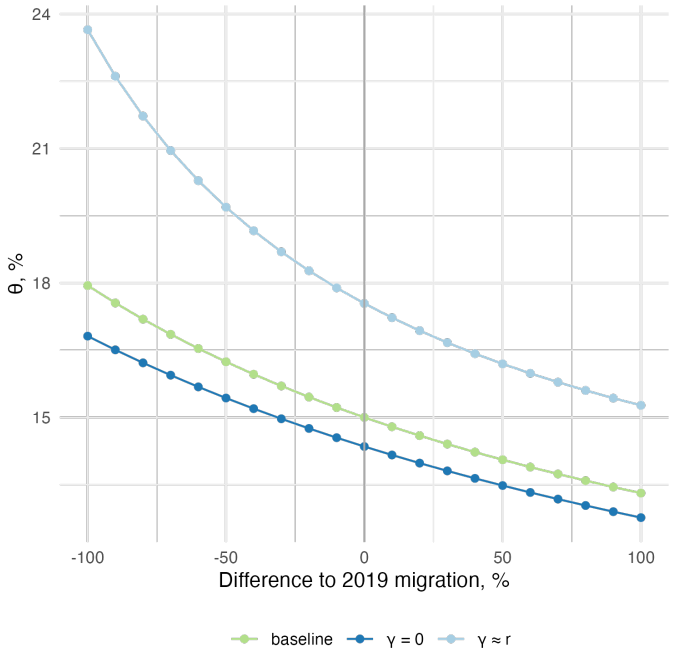
To see that the macroeconomic hypotheses do not play a role in the increasing costs on public finances of reducing migration, we also recompute the frontier between the rebalancing tax increase and the immigration level. It follows from the fact that D has a minimal influence on θ_τ that it also does not affect the convex relationship between migration and the tax adjustment. In Figure 11 we plot the frontier between the immigration level and θ_τ for the different assumptions regarding the discount factor.

E.2 Immigrants fertility

Generally, fertility rates are higher in developing countries. It is well known that this carries over to higher fertility in migrants. We also observe this demographic behavior in our data. The total fertility rate of residents born in non-EU countries is almost double that of the native population.

[25] In practice, we set $i = \gamma - \varepsilon$, with $\varepsilon = 10^{-7}$.

Figure 11: Frontier between the Level of Immigration and the Imbalance Factor Implied for Different Values of the Discount Factor, D



Note: The Figure shows the θ_τ value implied by different immigration scenarios. θ_τ is computed according to equation (7), under different values for the discount factor, D.

We perform sensitivity exercises to check to what extent the impact of migration relies on the fertility of non-EU immigrants. We change the assumption for this parameter with respect to the baseline, experimenting with two additional levels:

1. High: Constant to the base year This amounts to keeping constant the fertility of non-EU-born immigrants coming to the Euro-area in 2019. This is an optimistic scenario, as it seems more plausible that fertility will decline over time: the data on fertility rates of developing countries shows they have been decreasing in the last decades.

2. Low: Convergent to the natives' value The second alternative scenario is a rather pessimistic one. We set the fertility rate of non-EU immigrants to converge towards 1.6 children per woman, the same as nationals are expected to have by 2100.

We then, recompute the rebalancing tax increase. Table 5 shows this metric together with the θ_τ^{AKG} and the IBG. The differences are quite small across fertility scenarios. Even in the more extreme case, with immigrant fertility constant to the base year, θ_τ only increases 0.7 p.p. This is due to an increase in the costs related to education that is not offset by a larger working-age population in the long run. On the other hand, a smaller fertility rate leads to a smaller rebalancing tax increase, because of the same reasons. Nevertheless, the differences are not substantial for different non-EU-born fertility rates.

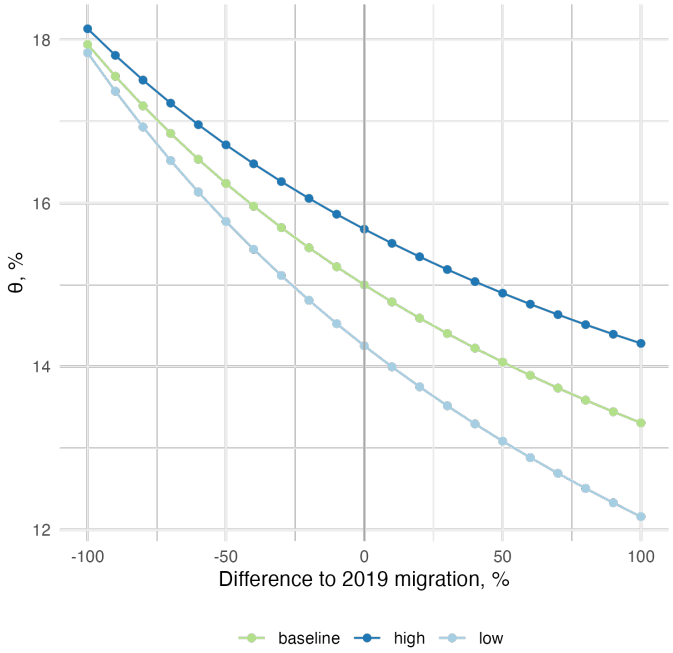
Table 5: Imbalance Metrics under Different Non-EU Immigrant Fertility Rates

Scenario	θ_τ	θ_τ^{AKG}	IBG
Baseline	15.0%	29.9%	5.53
High fertility	15.7%	31.1%	5.83
Low fertility	14.3%	28.8%	5.18

Note: θ_τ is computed according to equation (7). The other two metrics are described in the Appendix C.2.

We then, change the net migration scenario for the two additional fertility hypotheses. Figure 12 plots the frontier between the level of migration and the imbalance factor for the different immigrants fertility hypothesis. The convex relationship between the two variables still hold, showing that our result is robust to this hypothesis, as well.

Figure 12: Frontier between the Level of Immigration and the Imbalance Factor for Different Immigrants' Fertility Hypotheses.



Note: Each line of the Figure shows the relationship between θ_τ and the immigration value in the EA, for different scenarios of the non-EU born fertility rates. θ_τ is computed according to equation (7).

F Additional Figures

Figure 13: Primary Balance Decomposition by Demographic Characteristics for the Different EA Countries.

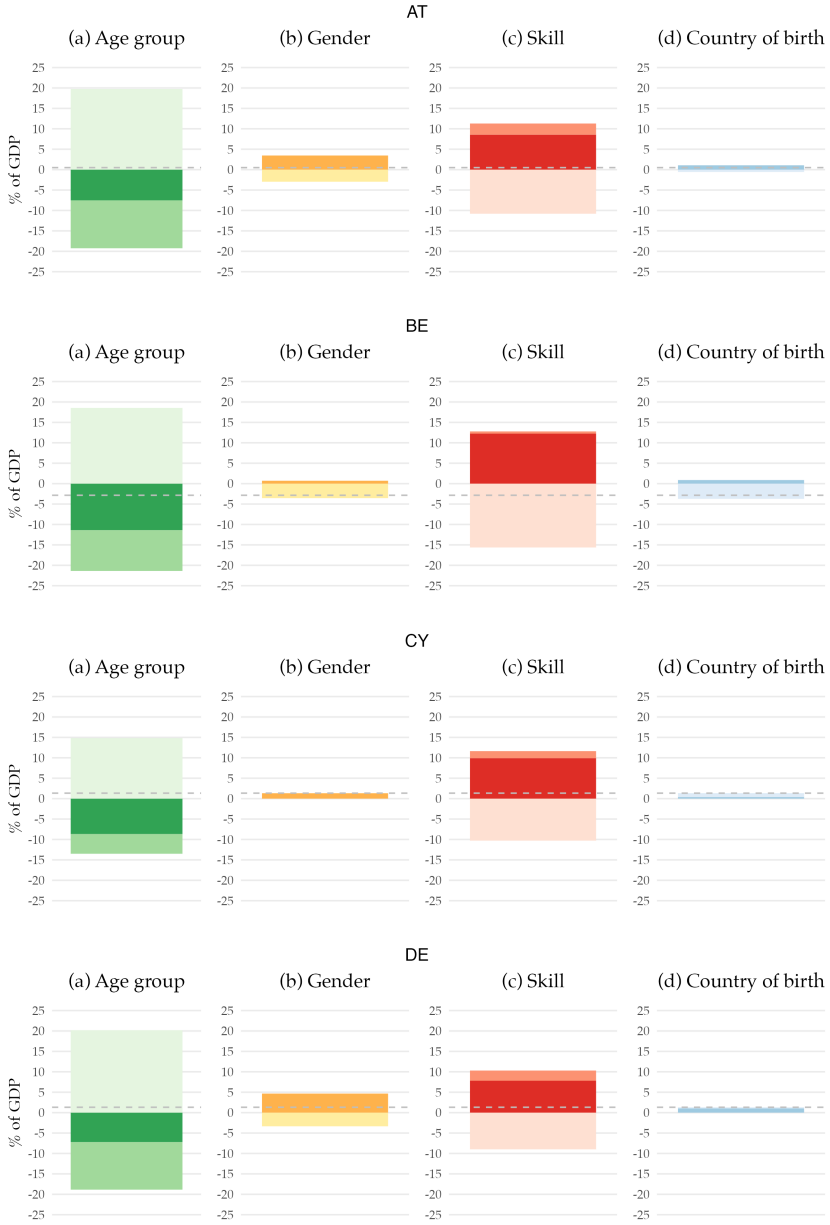
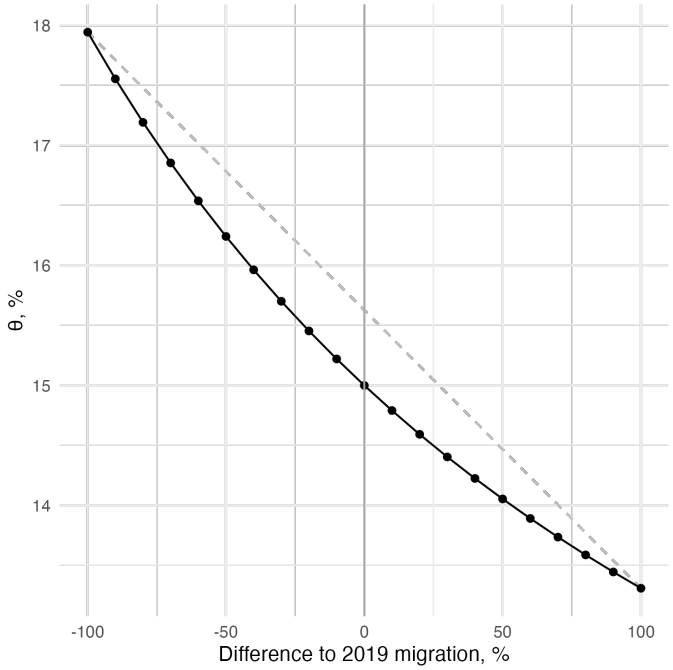
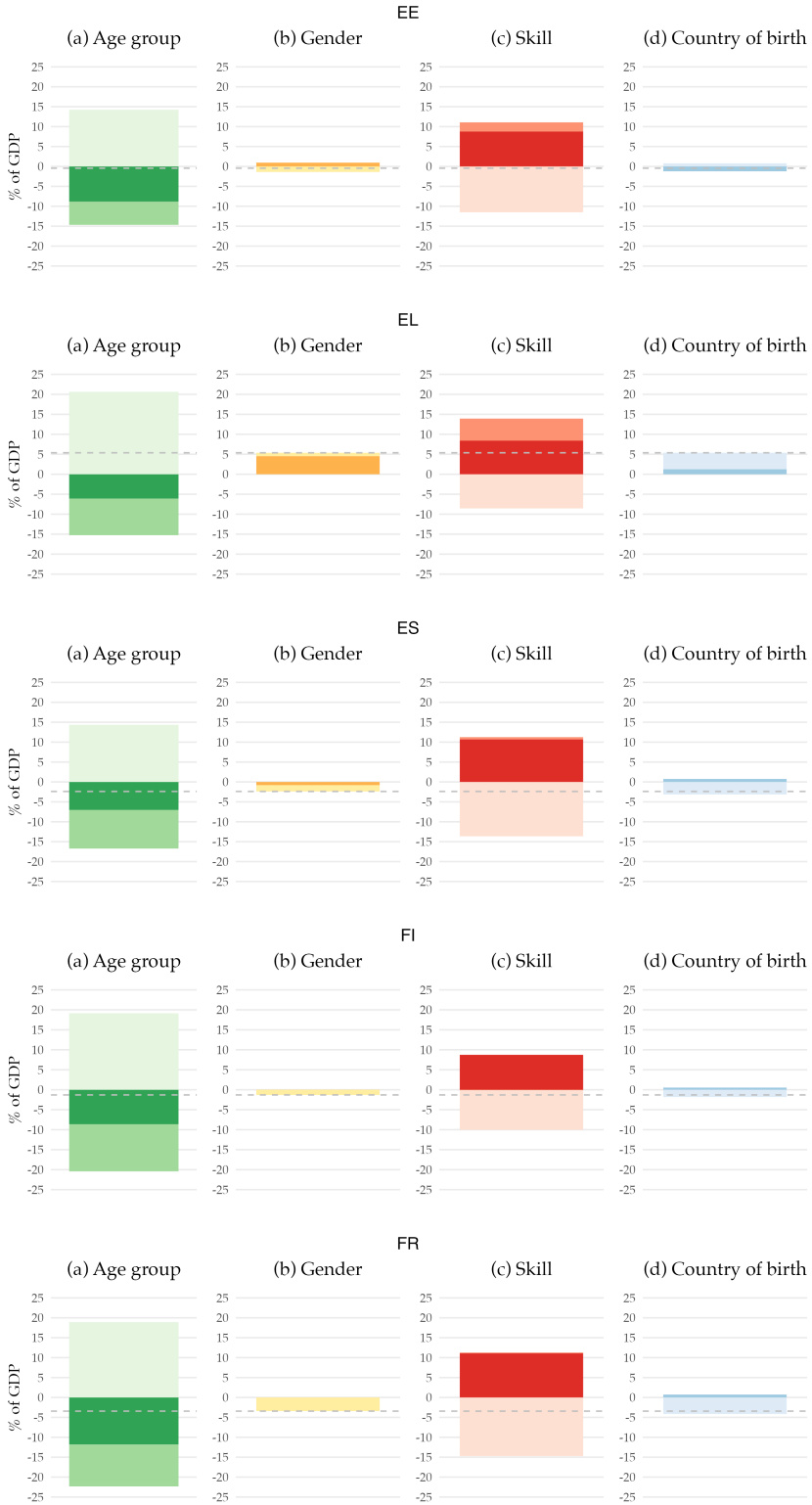
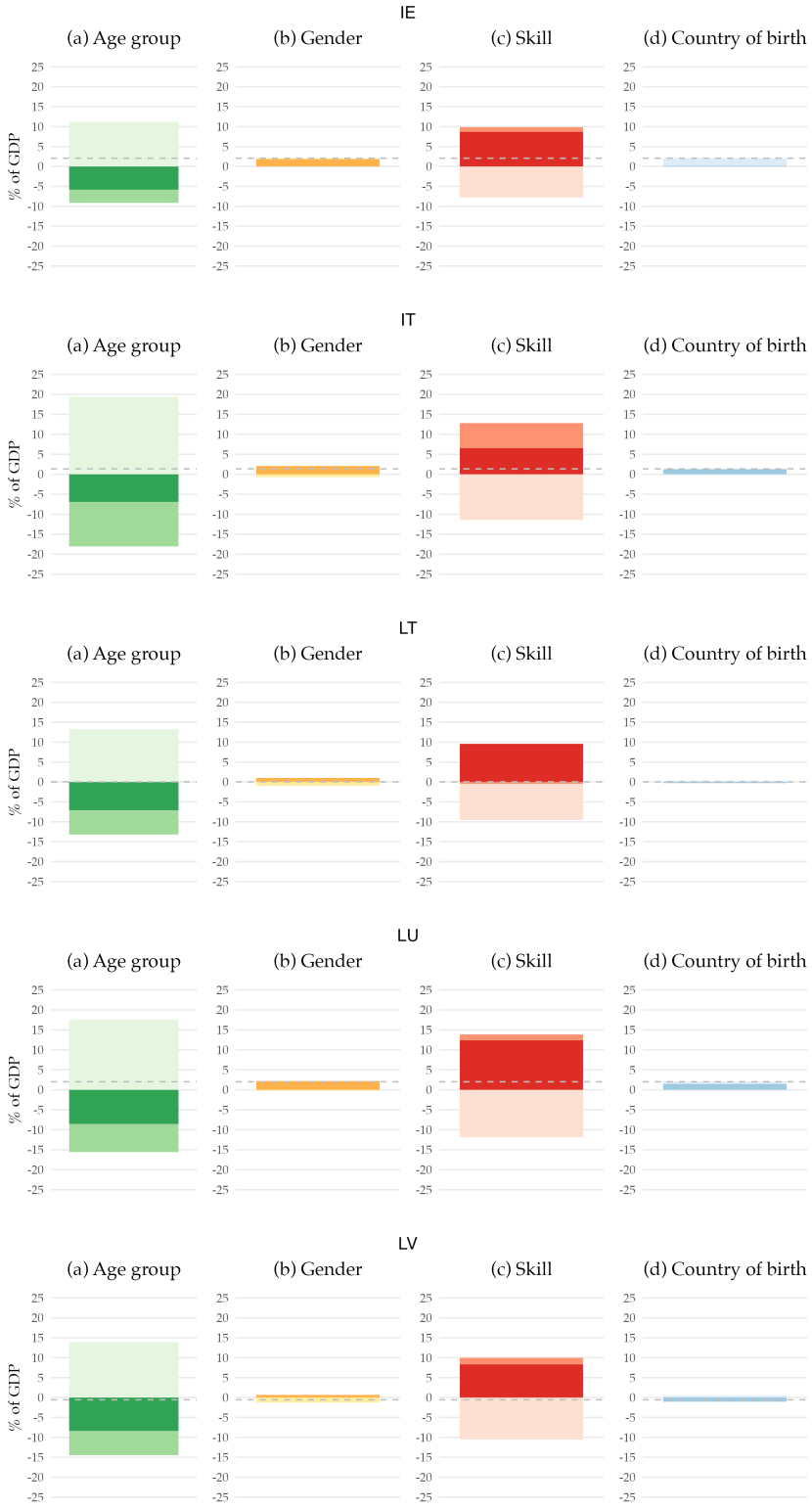


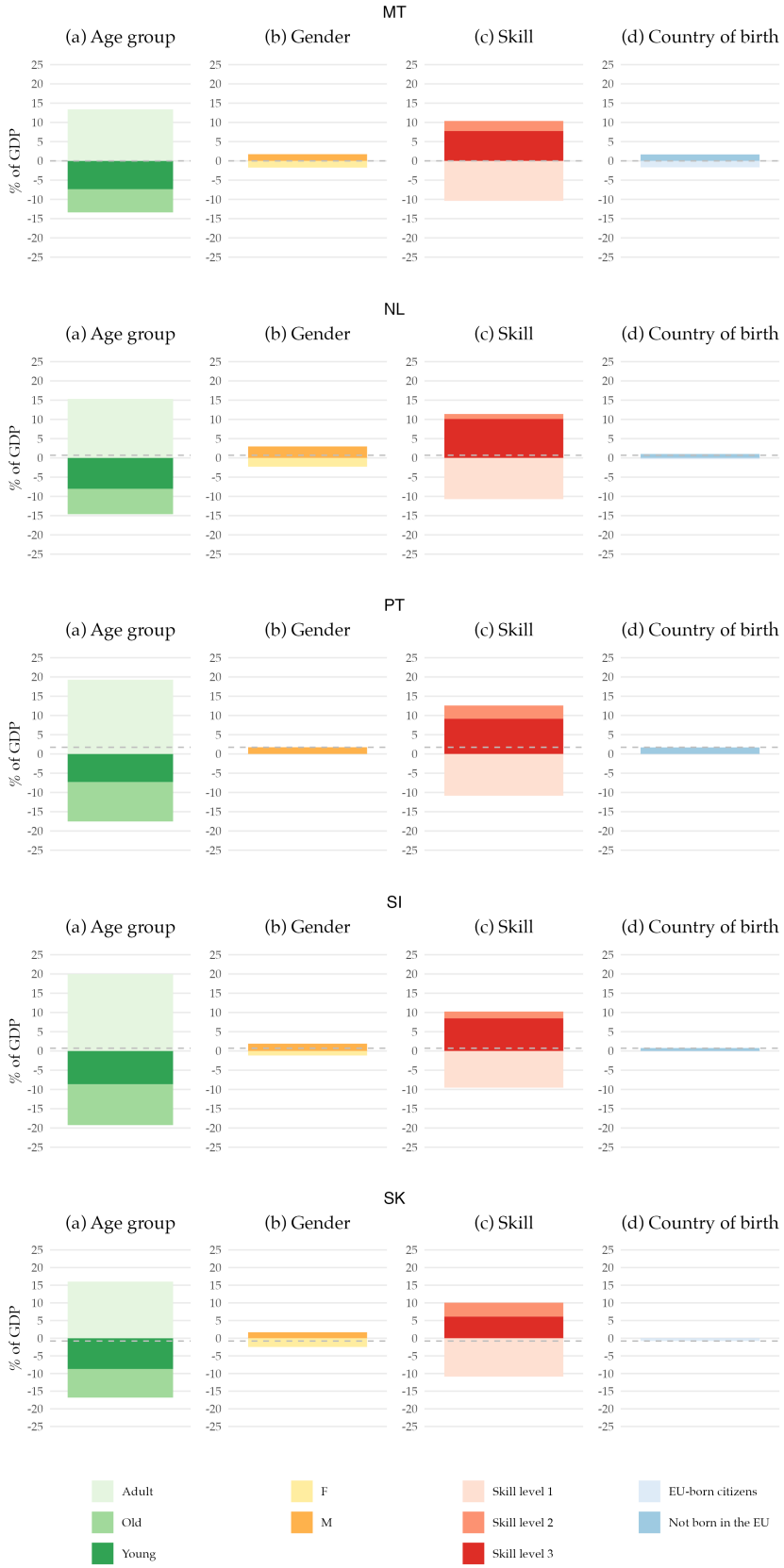
Figure 16: Frontier between the Level of Immigration and the Rebalancing Tax Increase Implied, θ_τ



Note: The figure shows the θ_τ value implied by different immigration scenarios. θ_τ is computed according to Equation (7). The dashed line is an auxiliary straight line connecting the two extremes.

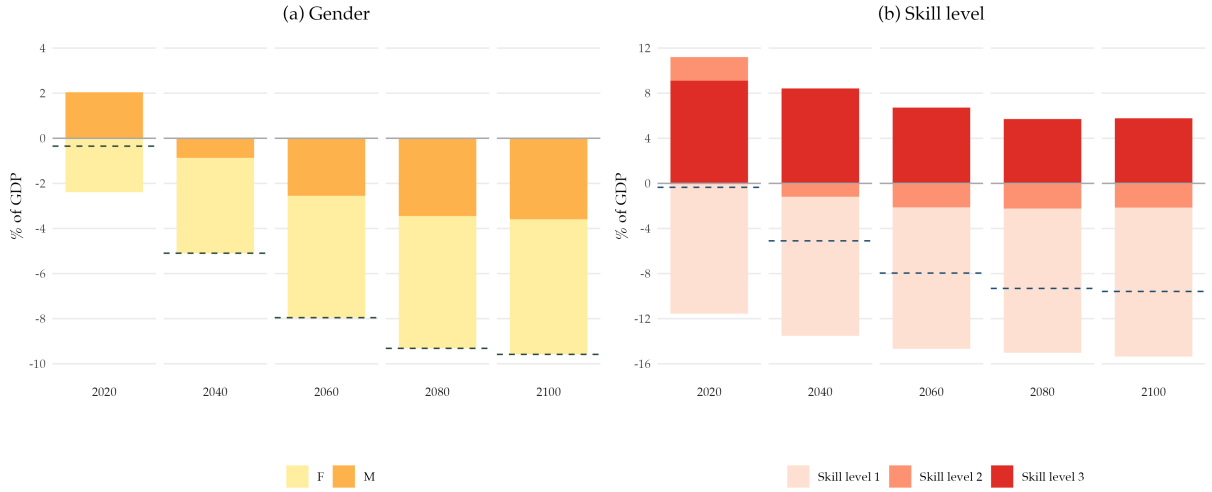

EE
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
EL
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
ES
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
FI
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
FR
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP


IE
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
IT
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
LT
(a) Age group
(b) Gender
(c) Skill
(d) Country of birth
% of GDP
LU
(a) Age group
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% of GDP



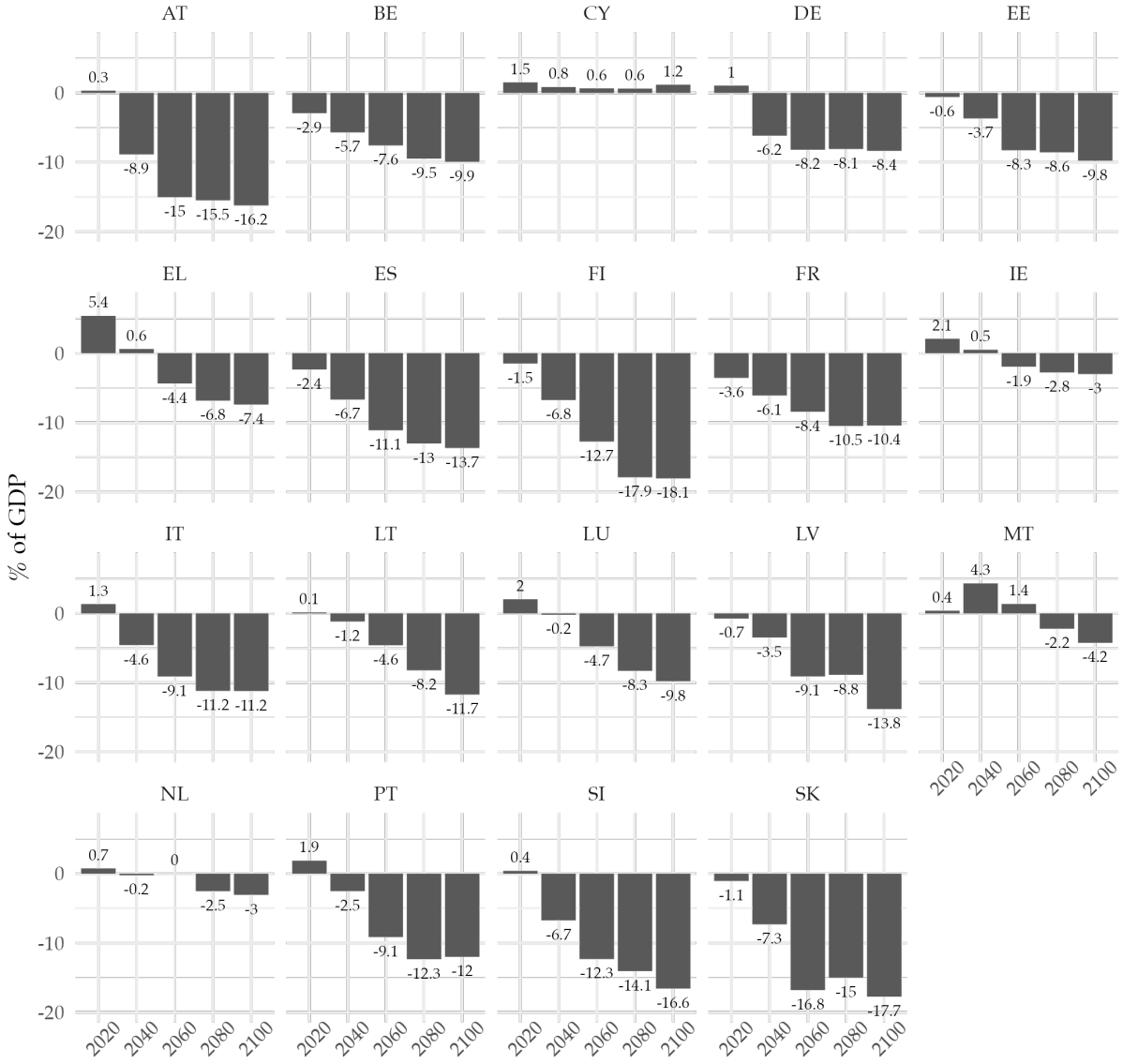
Note: The Figure has the primary balance decomposition by demographic characteristic for each country of the EA. This corresponds to the sum of revenues net of benefits attributable to agents with a given demographic characteristic in percentage of the 2019 potential GDP. The dashed line corresponds to the value of the primary balance in 2019. All values are in percentage of the potential GDP. The 2 letter codes key is: AT: Austria, BE: Belgium, CY: Cyprus, Germany: DE, Estonia: EE, Greece: EL, Spain: ES, Finland: FI, France: FR, Ireland: IE, Italy: IT, Lithuania: LT, Luxembourg: LU, Latvia: LV, Malta: MT, the Netherlands: NL, Portugal: PT, Slovenia: SI, and Slovakia: SK.

Figure 14: Counterfactual primary balance implied by the population projections decomposed by age group and country of birth.



Note: The dashed lines in the Figure represent the primary balance for selected years of the projection. The bars show the decomposition of the primary balance by skill-level (skill-level 1 corresponds to the population who did not complete high school, skill-level 2 corresponds to completed high school, and skill-level 3 corresponds to a completed college degree). All values are in percentage of the potential GDP.

Figure 15: Counterfactual primary balance implied by the population projections for the different EA countries.



Note: The Figure shows the primary balance implied by the population projections for selected years in percentage of the potential GDP. The 2 letter codes key is: AT: Austria, BE: Belgium, CY: Cyprus, Germany: DE, Estonia: EE, Greece: EL, Spain: ES, Finland: FI, France: FR, Ireland: IE, Italy: IT, Lithuania: LT, Luxembourg: LU, Latvia: LV, Malta: MT, the Netherlands: NL, Portugal: PT, Slovenia: SI, and Slovakia: SK.