The Costs of Building Walls: Immigration and the Fiscal Burden of Aging in Europe*

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Abstract

How much can immigration help relieve the burden of aging on public finances? We build population projections for each Euro area country, to measure how aging impacts public finances. We combine them with information on taxes and benefits by age, gender, education level, and country of birth. We find that fiscal sustainability requires a permanent tax increase of 12.7 percent on average across countries. Further, we uncover the negative and convex relationship between the intensity of net migration and the fiscal burden of aging. Building walls is costly: shutting down migration would increase the necessary tax increase by 2.1 percentage points. In contrast, increasing migration would help close the fiscal gap, albeit with diminishing effects. Still, the potential of migration outweighs that of fertility. Higher fertility helps by increasing the share of workers in the population but only in the very long run. In the short run, it mostly brings additional costs with children.

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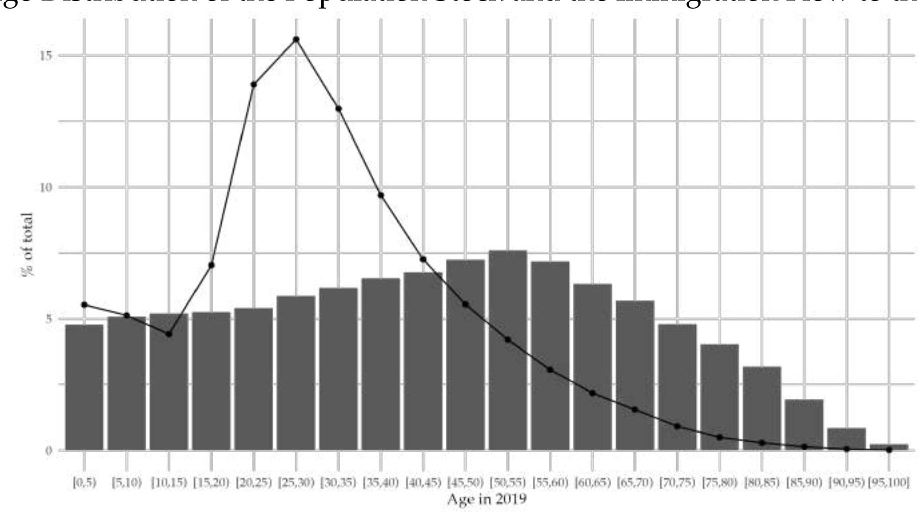
1 Introduction

What role can immigration play in dealing with the pressure on public finances created by population aging?

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).[1] These trends represent a burden for public finances – the fiscal burden of aging. Revenue from taxes and social contributions 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 resident population. Crucially, current immigration flows to Europe, depicted by the solid black line, are concentrated in the working-age group, unlike the resident population stock, represented by gray bars. Furthermore, immigration from non-EU countries is more fertile than the native population.

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.

Without immigration, European societies would be on the path to extinction. Fertility rates are generally below the replacement rate of 2.1 children per woman, so population is only sustained by an inflow of migrants, mostly from developing countries. This naturally leads the population

[1] According to the UN World Population Prospects, the old-age-dependency ratio is also projected to sharply increase in Australia, Canada, Japan, Korea, UK or USA.

share of immigrants (and their descendants) to increase over time. Overall, in these aging societies, migration sustains and influences the demographic structure of the resident population, rejuvenating it.

As this brings down the old-age-dependency ratio, immigration could indeed be a solution for the fiscal burden of aging. Yet, political platforms that portray immigration as a problem are gaining more and more traction. Currently, European countries are discussing policies to contain or even cut down immigration from the developing world.

In this paper, we assess the role of immigration as a solution for the fiscal burden of aging. Specifically, we focus on how restricting or expanding net migration inflows from developing countries affects demographic dynamics and, in that way, public finances. To do so, we begin by building our own population projection model, featuring a constant net migration inflow as in official projections, and then study the dynamics of the model under different scenarios for the size of this inflow.

Restricting immigration increases future dependency ratios, which is detrimental to public finances: these are the costs of building walls. We find that this relationship is nonlinear, i.e. each marginal restriction to immigration has increasing effects on dependency ratios, and therefore costs for public finances. Conversely, the benefits of expanding migration inflows diminish with each additional increase.

Building on these population projections, we then quantify the implications for public finances. Using multiple survey data sources, we estimate demographic profiles of taxes and benefits segmented by age, gender, education level, and country of birth, for each country of the EA.

We use these profiles to measure the fiscal burden of aging as follows: we keep the profiles fixed and, by applying them to our population projections, obtain counterfactual government budget series. We then calculate the tax increase required to ensure public debt sustainability under each 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.

Under our baseline projections, the primary deficit, currently close to zero, would become 8 percent of the potential GDP by 2060 and 9.6 percent by 2100. European countries, on average, would have to permanently increase the tax burden by 12.6 percent to ensure fiscal sustainability.

These baseline results rely on sustaining the net migration inflow of 2019 in the future, both in its overall size, 0.4 percent of the 2019 population,[2] and age-education structure, mostly composed of younger and lower-qualified individuals. Cutting this flow down to zero increases the fiscal burden of aging, measured by the rebalancing tax increase, to 14.8 percent, i.e. 2.1 percentage points higher than in the baseline. This means shutting down migration would entail an additional tax increase of almost 1 percent of GDP, every year.

Conversely, increasing migration would help reduce the fiscal gap, but with decreasing returns. Doubling the size of the net migration flow would result in a smaller rebalancing tax increase by

[2] This represents a total number of around 1.33 million people.

1.5 percentage points. The effects of increasing net migration flows are nonlinear: each increment to the flow has a smaller marginal effect on future dependency ratios, and therefore on the rebalancing tax increase.

As the native population is on the path to extinction, the population share of immigrants and their descendants is increasing over time. If we intensify the flow of migrants, this accelerates this trend, but each additional change moves it less and less, as the population share of immigrants approaches one.

With the increase of the share of immigrants and their descendants, the dependency ratio of the total population – a combination of native and immigrant groups – becomes closer to the dependency ratio of that group, which is smaller. A larger flow of migrants accelerates this trend such that each additional migrant has a smaller marginal effect on future dependency ratios and, therefore, on public finances; this is the source of the nonlinearity.

Furthermore, we show that boosting fertility is not an alternative to migration. If we start from a scenario with zero migration, and increase native fertility to the replacement rate (2.1 children per woman), there is no improvement to the rebalancing tax increase. This contrasts with the 2.1 percentage points reduction obtained by keeping the migration levels of 2019. The short-run effects of a higher population share of children, which are net beneficiaries from the government budget, outweigh the long-run effects of having more population in working ages at a later point in time.

All of our main results are robust to different assumptions for the fertility rates of immigrants and their descendants, as well as for different real productivity growth rates and interest rates. The nonlinearity we uncover is rooted 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.

Related literature and contribution Our paper follows a long literature investigating the contribution of immigration to public finances. This strand of the literature has mainly used fiscal cash-flow accounting models featuring rich population projections (e.g. Auerbach and Oreopoulos, 1999, Storesletten, 2003, Dustmann and Frattini, 2014). We innovate, first, by refining the methodology through considering multiple demographic dimensions in a transparent way, and we apply this methodology with fully consistent data to a large set of European countries. Second, our paper is the first to document the nonlinear link between immigration and the fiscal burden of aging.

A change to immigration flows has potentially many effects on the economy, such as labor markets or productivity, which could amplify the effects on public finances. A different strand of the literature has investigated these effects in general equilibrium models (e.g. Storesletten, 2000, Fehr et al., 2004, and Hansen et al., 2017) and with empirical approaches (e.g. D'Albis et al., 2019, Furlanetto and Robstad, 2019, and Colas and Sachs, 2024). While these effects are not negligible, the conclusion is that they do not affect the main results of the preceding literature. Further, the nonlinearity we uncover is also relevant for this literature, playing a role in any model taking population projections as an input.[3]

Our paper also provides updated and comparable estimates of the fiscal burden of aging for all Euro area countries. This is not only relevant for policy makers, but also for researchers addressing related topics, considering the lack of recent studies offering such estimates. Exceptions are Arevalo et al. (2019), who do not focus on immigration and use a more limited methodology without any dimensions beyond age and gender, Fiorio et al. (2023), who compute the fiscal net contributions of immigrants in Europe, but only 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 the effects of immigration policies.

Organization The rest of the paper is organized as follows. Section 2 describes the population projection model used. Section 3 presents the accounting methodology used that maps budget aggregates to demographic groups and maps it to the demographic projection to measure the impact of aging on public finance. Section 4 describes the data sources. Section 5 presents our population projections and the decomposition of the budget balance by different demographic characteristics. Section 6 describes the results on the role of migration in European public finances. Section 7 concludes.

2 Population Projection Model

In this section, we describe the model used to construct our demographic projections. We build projections for all countries of the EA by age, gender, country of birth and education level, using the classic cohort-component model. This is the standard method used by statistical offices worldwide, such as Census Bureau or Eurostat, in their official population projections.

The method takes the initial period population of each cohort and using series of fertility rates, mortality rates and net migration, projects how the population evolves over time. The population alive in period t with age a, gender g and country of birth c, given by $P_{t,a,g,c}$, evolves according to

$$P_{t,a,g,c} = (1 - m_{t-1,a,g,c})P_{t-1,a,g,c} + \bar{I}_{t,a,g,c}, \tag{1}$$

where $m_{t,a,g,c}$ is the mortality rate and $\bar{I}_{t,a,g,c}$ is the net migration of age a, gender g and country of birth c. Newborns in year t are given by

$$P_{t,0,g,c} = \sum_{a,g,c} P_{t-1,a,g,c} f_{t-1,a,g,c} \lambda + \bar{I}_{t,0,g,c}, \tag{2}$$

where $f_{t,a,g,c}$ corresponds to the fertility rate at time t of the population with characteristics a, g and c. λ is the gender breakdown of newborns, assumed constant.

[3] The estimates of the first approach tend to favor precision to bias, while the estimates of the second approach are less precise but typically unbiased – see Clemens (2022) for a discussion.

For each country, we use this model to project population stocks along three dimensions: age, gender, and country of birth. For the first dimension, we consider ages between 0 and 100, where $a = 100$ also includes individuals above 100. Regarding the second dimension, we allow for two genders, male and female. For country of birth, we consider two groups: "natives", which we will consider to be people born in the EU, and "migrants", people born outside the EU (which in the data come mostly from developing countries).

After projecting the population by age, gender, and country of birth, each cohort is split by education level. We consider three categories: primary, secondary and higher education.[4] The education levels of each cohort evolve over time as described below.

In implementing this population projection model, we take 2019 as the starting year. This avoids the pandemic effects that temporarily increased old-age population mortality. We run our population projection model until 2100. After that year, we impose population size and distribution to be constant in all dimensions.[5]

Fertility rates depend not only on age, but also on the country of birth. The fertility of natives is below the replacement rate of 2.1 children per woman. First-generation migrants have higher fertility rates, above replacement, but we assume that their descendants exhibit the same fertility as natives. Fertility of all groups varies over time. Mortality rates are common across education and country of birth groups, and slowly increase over time.[6]

The size of the net migration flow does not change over time. Further, the age, gender and education distribution of this flow also remains constant. So, every year, the inflow of net migrants has the same size and characteristics. In our main exercise, we vary the size of the net migration inflow, but other characteristics remain the same.[7]

To assign education levels to the population, we assume that education attained by new cohorts does not change over time. Concretely, for all year-of-birth groups, education rises until the age of 25 and then remains constant. Each cohort born before 1995 (i.e. 25 or above in 2019) keeps the education levels observed in 2019 throughout their lifetime. This means that the overall education level will increase over time since older cohorts, who generally have lower education, are replaced by younger, more educated ones.

Appendix C.4 describes some more details regarding how we build the population projections.

[4] Primary education corresponds to ISCED 2 or below in the International Standard Classification of Education (ISCED), secondary corresponds to ISCED 3 and 4, and higher corresponds to ISCED 5 and above.

[5] Interrupting the population transition at a later year does not affect our results.

[6] Data on mortality rates by education level are only available for a few EA countries. We could expect projected dependency ratios to be slightly higher if we incorporated such differences, as individuals with higher education levels tend to live longer.

[7] Although migration is volatile, official population projections, such as those done by Eurostat or Census Bureau, have similar assumptions regarding net migration evolution. They account for ongoing shocks that affect net migration inflows, but for the medium- and long-run they assume a constant net migration.

3 A Framework to Measure the Fiscal Burden of Aging

In this section, we describe the methodology that we use to map the budget aggregates into different demographic groups, which we combine with the population projections to measure the fiscal burden of aging. This is based on the seminal work of Auerbach et al. (1991), who proposes an alternative to standard public accounts that consider how demography affects public finances.

3.1 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:

$$B_t = G_t - T_t + (1 + i_t)B_{t-1}, \tag{3}$$

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

$$T_t = \sum_i T_t^i = \sum_i \sum_{x \in X} \tau_{t,x}^i P_{t,x}, \tag{4}$$

where $\tau_{t,x}^i$ is the average per capita government revenue of category i that is attributed to an individual of group x in the year t, and $P_{t,x}$ is the number of individuals of group 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:

$$G_t = \sum_i G_t^i = \sum_i \sum_{x \in X} g_{t,x}^i P_{t,x}, \tag{5}$$

where $g_{t,x}^i$ is the average per capita government expenditure of category i attributed to a person of group x in year t. For each budget item i, we refer to $\{\tau_{t,x}^i\}$ or $\{g_{t,x}^i\}$ as its demographic profile at time t. We estimate these profiles for the base year $\bar{t} = 2019$ and assume that they grow at the rate of labor productivity, γ, plus the inflation rate, π:[8]

[8] 2019 is a good year to estimate the demographic profiles as it does not suffer from any contamination from the health crisis and subsequent cost-of-living crisis.

$$\tau^i_{t,x} = \tau^i_{\bar{t},x} \prod_{j=\bar{t}+1}^{t} \left(1+\gamma_j\right)\left(1+\pi_j\right), \text{ for } t > \bar{t}, \tag{6}$$

and similarly for government expenditure items. This framework is isomorphic to 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). In Appendix A we describe this model.

3.2 Measuring the Fiscal Burden of Aging

We next derive a metric for the fiscal burden of aging. We assume that the demographic profiles do not change. 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 induced by aging trends under different demographic scenarios.

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 (3), starting in the base year $\bar{t}$:

$$\sum_{s=0}^{\infty} \prod_{j=1}^{s} \frac{G_{\bar{t}+s}}{\left(1+i_{\bar{t}+j}\right)} - \sum_{s=0}^{\infty} \prod_{j=1}^{s} \frac{T_{\bar{t}+s}}{\left(1+i_{\bar{t}+j}\right)} + B_{\bar{t}-1} = \lim_{s\to\infty} \prod_{j=1}^{s} \frac{B_{\bar{t}+s}}{\left(1+i_{\bar{t}+j}\right)}. \tag{7}$$

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 (7) 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 group x, and a starting value for public debt $B_{\bar{t}-1}$, we can derive the adjustment factor, θ_τ:

$$\sum_{s=0}^{\infty} \sum_{i} \sum_{x\in X} D^s \left[g^i_{\bar{t},x} - (1+\theta_\tau)\tau^i_{\bar{t},x}\right] P_{\bar{t}+s,x} + B_{\bar{t}-1} = 0. \tag{8}$$

The adjustment factor θ_τ represents the permanent increase, across all revenue categories, and groups, 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.[9]

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.[10]

Note that θ_τ is positive when the discounted sum of the contributions to the budget is smaller than the benefits paid by the government, meaning that restoring fiscal balance requires a tax increase. As we can see in Equation (8), since the demographic profiles are fixed , the value of θ_τ is larger if the demographic groups for whom $\sum_i g^i_{\bar{t},x} > \sum_i \tau^i_{\bar{t},x}$ grow more over time, and smaller in the opposite case. As we shall see in the data, young and retired groups are net beneficiaries from the budget and the working-age group is a net contributor. Therefore, the value of θ_τ is related with the evolution of 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.[11]

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.[12] We show these two measures in Section 6, alongside the rebalancing tax increase. In Appendix C.2 we show the formulas to compute these two metrics.

[9] Blanchard (1990) argues why an indicator of this type is the most appropriate measure of long-run fiscal sustainability.

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

[11] 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.

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

4 Data

In this section, we describe the data sources we use to build our population projections as described in Section 2, and to estimate the demographic profiles of the different revenue and expenditure items as described in Section 3. We obtain these two objects for all countries that were part of the EA in 2019.[13]

Data for the population projections comes from Eurostat. Specifically, we use the EUROPOP2019 central projection forecasts for mortality and fertility rates (Eurostat, 2020). Furthermore, we also obtain from Eurostat the population breakdowns by education and country of birth for 2019.

To estimate the demographic profiles for the different budget items we need to have individual micro-level data with the demographic characteristics of individuals, their payments of 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.

Individual microdata on taxes and benefits come mostly from the EU Statistics on Income and Living Conditions (EU-SILC) survey. This data set offers timely and comparable cross-sectional and longitudinal data on income, poverty, social exclusion, and living conditions. For our purpose we only use the cross-sectional dimension of the data set. We use individual data on labor income, income and property taxes, and social transfers, including pensions to estimate $\tau_{\bar{t},x}$ and $g_{\bar{t},x}$. This allows us to estimate the demographic profile of personal income tax, social security contributions, property tax, old-age pension, survival pension, disability pension, unemplyment benefits, and sickness allowance.

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, which we use to allocate value-added tax to each group x. 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.[14]

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 expenditure, we use data from Eurostat that report expenditures by level of studies. [15]

In total, we estimate the demographic profile of 12 different budget items, that cover about two-

[13] 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).

[14] 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.

[15] We allocate primary education (ISCED 0-1) expenditures to ages 2 to 11, secondary (ISCED 2-4) to ages 12 to 18, and tertiary or higher education (ISCED 5-7) to the population aged between 19 and 25 who completed at least secondary education. This represents a typical situation in European countries, as described in Motiejunaite-Schulmeister et al. (2022a).

thirds of the budget. The remainder of the budget cannot be mapped to a demographic group, 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 the revenues of these budget items, we uniformly distribute them to all individuals older than 18 years, and for the expenditures, we distribute them uniformly, independent of any demographic characteristic.[16]

Appendix D has the list of variables used from the different data sources. The demographic profiles estimated of each budget item are provided in Appendix F. Appendix C.3 has additional estimation details of the profiles.

5 Population Projections and Demographic Profiles of the Government Budget

In this section, we describe the estimation results of the two building blocks of our framework. First, we show the demographic projections implied by the population projection model of Section 2. Second, we show the government budget demographic decomposition implied by the profiles estimated according to Section 3.

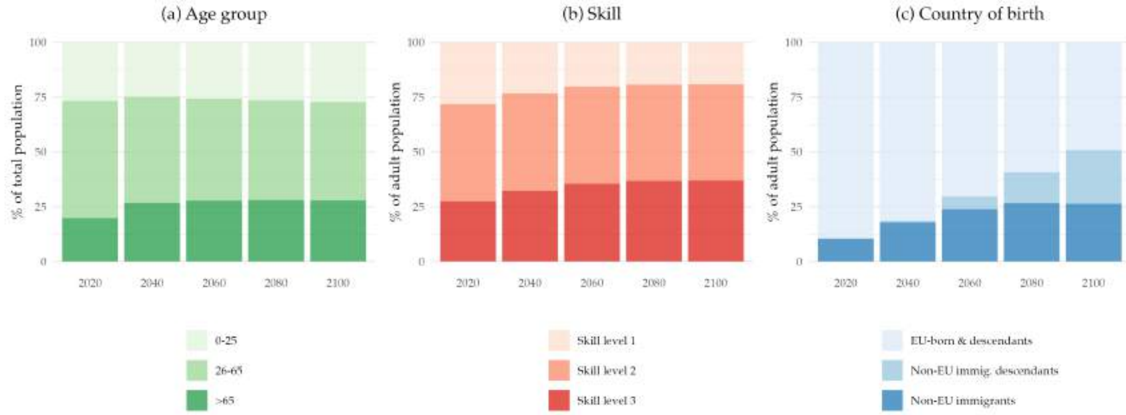
5.1 Population Projections

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 education level according to Equations (1) and (2), until 2100. After that year, we assume a constant population. Figure 2 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 working-age population) increases from 0.89 in 2020 to 1.13 by 2100, which is in line with the Eurostat projection. Panel (a) shows that the share of the working-age 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, not plotted, is projected to remain constant, with the female population making up slightly half of the total population.

[16]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.

Figure 2: 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, working-age, and old age). Panel (b) presents the skill level distribution as a percentage of the adult population. Panel (c) depicts the distribution of country of birth as a percentage of the adult population. The gender distribution is not plotted.

Our demographic forecasts also imply the skill distribution of the adult population will change, as panel (b) 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 (c) 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.

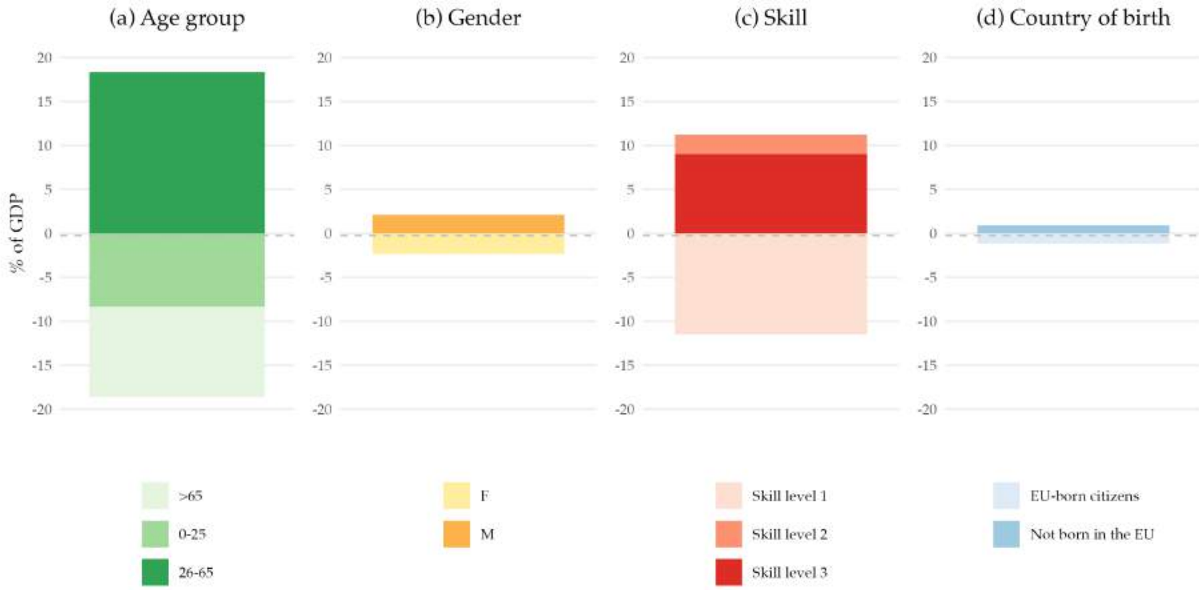
5.2 Demographic Profiles of the Government Budget

Using the microdata sources described in Section 4, 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. These are the demographic profiles that we describe in Section 3 and that we show in Appendix F for each country and budget item, as well as the average demographic profile across the EA countries. 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 3 shows that decomposition for the EA as a whole.[17]

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

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

Figure 3: 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.

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 working-age 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.

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: a lower skill level 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, non-EU immigrants have a positive net contribution to public finances, whereas the net contribution of the native group is negative. This result is also evident in Fiorio et al. (2023).

6 The Role of Immigration in Reducing the Fiscal Burden of Aging

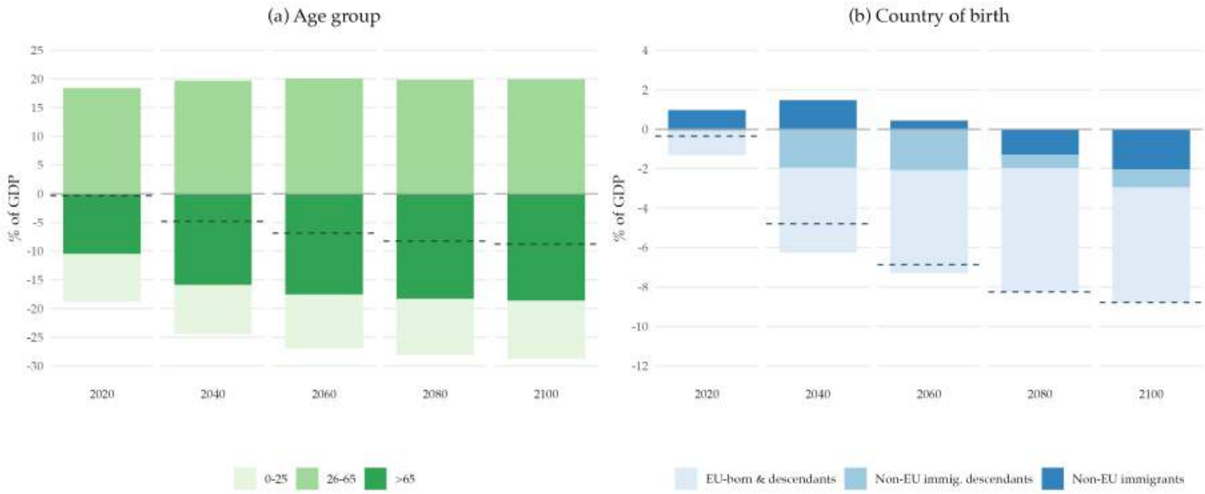
In this section, we look at the counterfactual government budget implied by our population projections. First, we use it to assess the fiscal burden of aging and look at the contributions of different age and country of birth groups over time. Then, we present our main results on the impact of changing the net migration flow on public finances. The section closes with a list of robustness exercises.

6.1 The Fiscal Burden of Aging in Europe

In the demographic projections described in Section 5, the population of the EA will age over the coming decades, with the dependency ratio increasing substantially. As this means that the share of net beneficiaries in the population will increase, this trend will put pressure on the sustainability of public finances – the fiscal burden of aging. To measure this burden, we build the counterfactual government budget implied by our customized population projections, keeping fixed the demographic profiles of different budget items.

In Figure 4, we plot the resulting primary balances for selected years of the projection. The initial deficit of 0.2 percent of 2019 potential GDP 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. Although with varying intensity and speed, we can observe the same trend across the EA countries. See Appendix F for the projected primary balances at the country level.

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. 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 governments in the EA need to increase taxes to rebalance public finances? To answer this question, we look at the rebalancing tax increase, θ_τ, our headline fiscal sustainability indicator derived in Section 3. For presentation purposes, we compute the weighted average across countries, using their respective 2019 potential GDP as weights. Governments across the EA would need to increase taxes by 12.7 percent, for everyone and permanently.[18] If the tax increase affected only generations born after 2019, it would need to be 52.6 percent.

We now examine the net contributions to the overall budget balance made by different age and country of birth groups over time.[19] 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 period, with a slight increase in the later years. Similarly, the positive contribution from the working-age 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 group. 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 recipient. This is due to life-cycle effects that also occur in this case: when these individuals immigrate, they are mostly at working age and hence contributing positively to the

[18]If, instead of taking a weighted average of country-specific adjustments, we aggregate the countries' budgets into a common EA budget, the rebalancing tax increase would be 15%.

[19]For completeness, in Appendix F we show the decomposition of the primary balance by gender and skill level.

government budget. Eventually, they will also retire, becoming net beneficiaries. As a whole, the immigrant group is also aging, and this is not compensated by the relatively younger new immigration flow nor by return migration of non-EU-born individuals at older ages.

Throughout the projection period, the descendants of non-EU immigrants have a negative contribution. This negative contribution comes from the age composition of this subpopulation.[20] In the first years of the projection, they are mostly benefiting from education services provided by the government and hence have a negative contribution. This negative net contribution shrinks as they start entering the labor market but never reaches a positive value. In the later years of the projection, it increases again as older members of this group start to enter retirement.

In our baseline scenario, which considers a stable net migration flow at 2019 levels, the fiscal burden of aging in the Euro area is substantial. It is summarized by a rebalancing tax increase of 12.7% on average across countries, in spite of the positive net contribution of immigrant groups. Next, we analyze the extent to which migration can help mitigate this burden, if it were to increase, or how much heavier the burden would become in the absence of immigration – the fiscal costs of building walls.

6.2 The Costs of Building Walls: The Nonlinear Effects of Immigration

We now use our framework to predict how different intensities of the net migration flows impact fiscal balances over time.

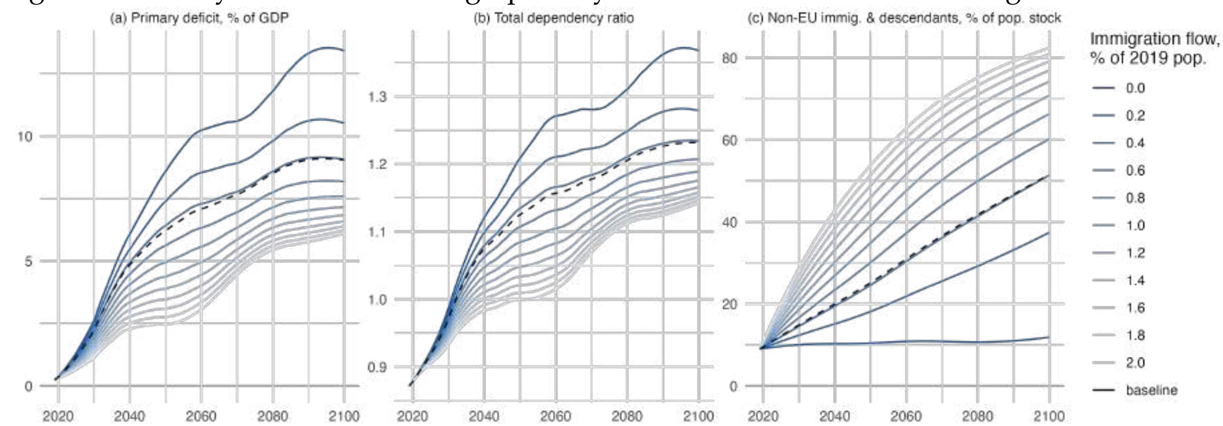
6.2.1 The nonlinear effects of immigration on the primary deficit

Our baseline projection assumes a constant yearly net migration flow from non-EU countries at the level observed in 2019, around 0.4 percent of the EA population in that year. We then explore various demographic scenarios where we change the intensity of net migration flows as a share of the 2019 population. The age/gender/skill distribution of incoming net migration is kept equal to that observed in 2019, and only the scale of net migration flows changes.[21]

Figure 5 shows the results of this exercise, plotting over time the projections of different variables for each migration scenario. Panel (a) shows the primary deficit, panel (b) shows the total age dependency ratio and panel (c) the share of non-EU immigrants and their descendants in the total population.

[20] We assume that the skill composition of the descendants of both natives and immigrants is the same.
[21] This net migration flow includes return migration, that is, the population returning to their origin countries.

Figure 5: Primary Deficit and Demographic Dynamics under Different Net Migration Scenarios



Note: Panel (a) shows the projected primary 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. Panel (c) shows the share of natives in the population stock for the same net migration scenarios. The dashed line in all three panels corresponds to the baseline scenario.

Panel (a) shows that, regardless of the level of migration, the current small primary deficit will increase and stabilize around 2080. These projected deficits are essentially driven by the dependency ratio, as suggested by comparison with panel (b). Young and old individuals are net receivers of the government budget, whereas working-age individuals are net contributors, as previously shown in Figure 3. With aging, the share of net contributors in the population decreases, as evidenced by the rise in the dependency ratio, leading to an increase in the deficit over time. We remark that even in this rich projection exercise, which considers several dimensions (age, education, country of birth and gender), the dynamics of the deficit are still tightly linked to the dependency ratio.

The Figure also compares different scenarios for the net migration flow, ranging from zero to 2 percent of the 2019 total population. These are depicted in the charts with different colors, where lighter shades represent larger immigration flows. The results show a positive relation between net migration and fiscal sustainability. A smaller migration inflow leads to larger primary deficits, while larger flows result in smaller deficits. This is mainly due to the age structure of net migration flows being more concentrated in the working ages compared to the resident population (recall Figure 1). For this reason, a more intense migration inflow leads to lower dependency ratios, and therefore smaller fiscal deficits.

The relationship between net migration flows and primary deficits is not linear. As panel (a) also shows, increasing the size of the net migration flow has diminishing negative effects on future deficits, while constraining migration has increasing effects: the fiscal costs of "building walls" increase with the size of the restriction. Note that the different migration scenarios in the chart are equally spaced, by increments of 0.2 percentage points. At higher migration levels, the differences between scenarios become smaller, while with each restriction to the migration flow, the differences between scenarios widen.

To explain this result, we turn to panel (c) of Figure 5, which shows the share of non-EU immigrants and their descendants in the total population. The projected population can be seen as a combination of two separate groups: a "native" group and a "immigrant" group, comprising the stock of immigrants living in the EA in 2019, new immigrants, and their descendants. The native group is on the path to extinction, while the immigrant group is not, because it is sustained by a constant inflow.[22] As such, for any level of the immigration flow, the share of the "immigrant" group in the total population increases over time.

A stronger constant inflow will generate a larger "immigrant" population and, as the native population is shrinking, the "immigrant" population share will be higher. This is why we observe, in panel (c), that scenarios with higher net migration imply a larger "immigrant" share at any point in time.

Since the net migration inflow is constant, its impact on the size of the "immigrant" population cumulates over time: an inflow larger by M persons implies an additional $M + (M + M) + ... + t \times M$ immigrants at year $\bar{t} + t$ (minus those deceased in the meantime). Therefore, higher net migration scenarios generate faster growth of the "immigrant" population share, as the chart demonstrates.[23] Also, as the native group is invariant to the size of the inflow, each marginal increase to the flow has decreasing effects on the population share of the "immigrant" group.

6.2.2 Implications for the fiscal burden of aging

These demographic dynamics lead to the nonlinearity between the intensity of immigration flows and the primary balance. As the immigrant population share increases over time, this subpopulation's age structure plays a greater role in driving the overall primary deficit. Since the immigrant population exhibits lower dependency ratios, they contribute to shrink the deficit. As a result, stronger net migration inflows lead to smaller deficits, but each additional increment to the inflow has a decreasing impact on the deficits.

This mechanism explains why many previous studies reached the conclusion that immigration cannot fully solve the public finance sustainability issues faced by developed economies (see Preston, 2014, for a review).[24] Such studies, following the standard procedure in official demographic projections, also assumed a constant immigration inflow.

We now look at the rebalancing tax increase, θ_τ, under the different scenarios for net migration. Figure 6 draws the frontier between the net migration flow and θ_τ. As this Figure shows, the tax

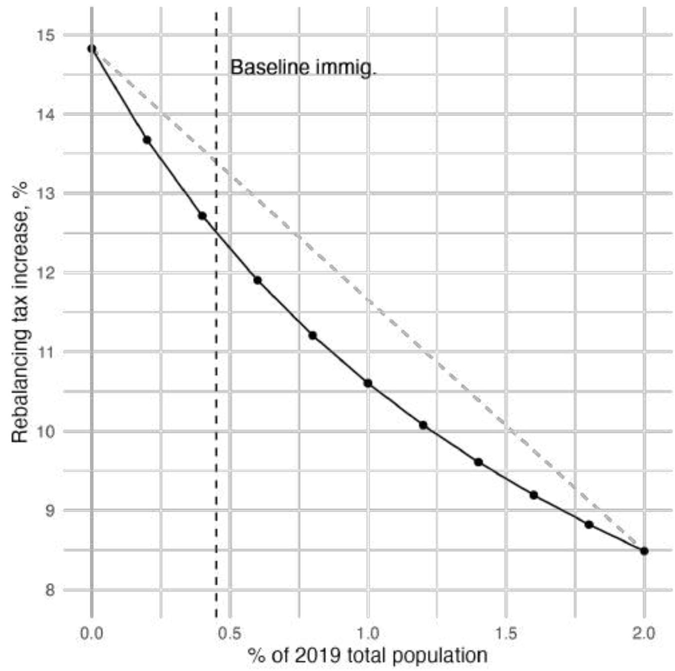
[22]Recall that immigrants' descendants are assumed to have the same fertility rates as natives. Therefore, the immigrant group is sustained only by the constant inflow of new immigrants (stationary through immigration, as explained in Appendix B).

[23]The impact on the growth of the immigrant population can be stronger with higher immigrant fertility. However, the point made here is valid with any level of fertility, even if it is below replacement. Our robustness exercise in the Appendix E.2 indicates that the role of fertility is small compared to the cumulation effect described.

[24]The effects of the intensity of immigration flows on the dependency ratio in populations where native fertility is below replacement have been explored by demographers (see e.g. Schmertmann, 1992). In that spirit, in Appendix B, we explore a 3-generation model with constant immigration flows. We show how the stationary population dependency ratio is invariant to the size of the flow; the intensity of flows changes only the transition path for the dependency ratio.

adjustment necessary to restore sustainability becomes more severe with a restriction to immigration flows, due to its effects on future primary deficits as shown in Figure 5. If net migration from non-EU countries is cut to zero, the rebalancing tax increase widens by 2 percentage points – this means a permanent tax increase by almost 1% of the EA GDP, every year. Without immigrants coming in, the fiscal burden of aging becomes far heavier.

Figure 6: Frontier between the Level of Net Migration and the Rebalancing Tax Increase, 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 diagonal dashed line is an auxiliary straight line connecting the two extremes. The vertical dashed line indicates the baseline net migration value.

The chart also shows that the relationship between net migration and the fiscal burden of aging is nonlinear and convex. Each marginal reduction of the net migration flow has an increasing cost for public finances. If, hypothetically, immigration flows doubled in size (from the current 0.4% to 0.8% of the 2019 population), the rebalancing tax adjustment would decrease by 1.5 percentage points. These gains are smaller in size, by about half, compared to the costs of shutting down migration. In this sense, increasing migration has diminishing returns for public finances. Table 1 shows the rebalancing tax increase, and two other metrics, for these three scenarios described.

A net migration inflow of 2%, the highest in our scenarios, is very likely unattainable for most European countries, looking at the current levels. This means that immigration cannot per se eliminate the fiscal burden of aging, since even after increasing migration flows by a factor of 5, fiscal sustainability would still require an 8.5% rebalancing tax increase.

Table 1: Imbalance Metrics in Different Migration Scenarios

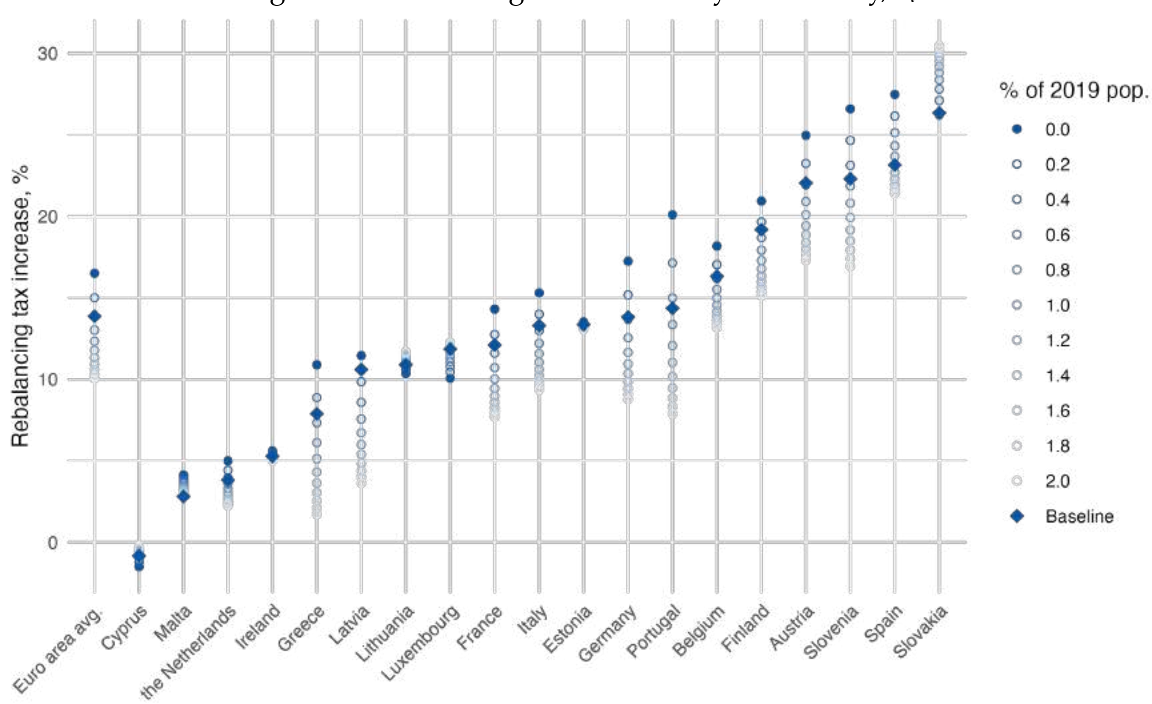
Size of net migration flow	θ_τ	θ_τ^{AGK}	IBG
0.4% of 2019 pop. (baseline)	12.5%	52.6%	3.15
0.8% of 2019 pop. (doubling)	11.2%	46.5%	2.56
0.0% of 2019 pop. (shut-down)	14.6%	96.6%	2.49

Note: The value of θ_τ reported corresponds to the weighted average of the rebalancing tax increase of each country computed according to Equation 8, 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.

Rebalancing tax increases at the country level Up until this point all the results reported are for the EA. This masks substantial differences across countries. For example, Spain has a dependency ratio of 0.52 dependents per working-age person, whereas France has a dependency ratio of 0.64. Future demographic trends are also heterogeneous, with some countries projected to have higher fertility rates than others.

Along with the different aging trends, our results on the sustainability of the public finance situation are also diverse across countries. Figure 7 reports the country-specific rebalancing tax increase under different net migration scenarios. In the baseline, countries like 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, Malta and the Netherlands are the countries with the smallest rebalancing tax increase.

Figure 7: 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.

By comparing the different net migration scenarios with the baseline, we can see in which countries migration flows are more important. In the plot, for each country, the spread between the circles and the diamond, that indicates the baseline θ_τ, shows how changing the net migration flows affects the sustainability of public finances. 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 size of the effect of changing net migration on θ_τ depends on several factors. First, the age and skill distribution of the net migration inflow in comparison with the native's distribution in each country. If net migration is more concentrated in working age skilled individuals, the benefit for public finances will be larger. Second, if migrants have lower fertility or higher mortality this would also lead to larger benefits of net migration. Finally, if baseline net migration is small, the benefits from increasing it will be higher due to the nonlinearity described above.

6.2.3 Is boosting fertility a solution?

Policies promoting fertility are often seen as an alternative to migration to deal with the fiscal burden of aging. We consider this option in our framework, in an exercise where we change native fertility levels, shown in Table 2. We take as a starting point the zero net migration scenario, which features the observed levels of native fertility, at around 1.6 children per woman (Scenario A in the table). We then compare this with two alternatives: first, a higher fertility rate scenario, where we set it at the replacement level, 2.1 children per woman, and keep net migration at zero (Scenario B);[25] second, we keep fertility at around 1.6 children per woman, and set net migration flows at their 2019 levels (Scenario C, also our baseline in the main results above).

In the first alternative considered (B), when native fertility is higher, the rebalancing tax increase is almost unchanged, even increasing slightly compared to Scenario A. In contrast, when we increase the net migration flow to 2019 levels (Scenario C), the rebalancing tax increase falls by 2.1 percentage points compared to Scenario A (as previously shown in Figure 6). The high fertility scenario generates higher dependency ratios and, therefore, projected primary deficits, compared to the scenario with no migration, during the first 40 years of the projection. This effect is compensated by a lower long-run primary deficit.

Intuitively, in the short run, higher fertility only increases the population share of children, who have a negative net contribution to the budget. This increase would come at the same time as the share of old-age population is growing due to the large "baby boomer" cohort entering retirement. The benefits of higher fertility, in terms of a larger share of working-age population, only come far

[25] Note that this is a highly optimistic scenario regarding the potential of policies to increase fertility. Even if policies were successful, fertility is a slow moving variable.

Table 2: Imbalance Metrics in High Native Fertility Scenario

Scenario	Native fertility	Net migration flow	θ_τ	θ_τ^{AGK}	IBG
A	Baseline (1.6 in 2020+)	0.0% of 2019 pop.	14.6%	96.6%	2.49
B	High (2.1 in 2020+)	0.0% of 2019 pop.	15.1%	68.8%	3.25
C	Baseline (1.6 in 2020+)	0.4% of 2019 pop. (baseline)	12.5%	52.6%	3.15

Note: The value of θ_τ reported corresponds to the weighted average of the rebalancing tax increase of each country computed according to Equation 8, 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.

later.[26] For these reasons, fertility is not an alternative to migration, as an instrument to moderate the increase in the dependency ratio and, therefore, the fiscal burden of aging.

6.3 Robustness Exercises

Interest rate and productivity growth rate In our baseline exercise, we set the productivity growth rate, γ, the nominal interest rate, i, and the inflation rate, π, equal 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, equal to 0.986. Given that our main results rely on projected values, we tested if the nonlinearity between migration flow size and the rebalancing tax increase depends on the assumption for D. In Appendix E.1, we compute the rebalancing tax increase for different values of D, and plot the frontier between θ_τ and the level of migration in each case. We show that the convexity holds for the different cases considered.

Fertility rate of immigrants All the results shown so far rely on the same assumption for the fertility rate of first-generation immigrants, which follows a convergent path towards 2.1 children per woman by 2100. This assumption could have an impact on the measured fiscal benefits of migration. In Appendix E.2, we test for that by computing the rebalancing tax increase with different assumptions for the immigrant fertility rate, as well as the frontier between θ_τ and the level of migration. The convexity is observed across these different scenarios.

7 Conclusion

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. At the same time, the European population is aging. The ongoing increase in the dependency ratio puts pressure on public finances – the fiscal burden of aging.

[26] This is why, unlike our preferred metric, the θ_τ^{AGK} result improves with higher native fertility, as it places a larger weight on more distant periods.

In this study, based on detailed data on taxes, benefits, and demographic dynamics, we revisited the question of how immigration can help relieve this burden. Increasing net migration flows to Europe from non-EU countries, composed mainly of working-age individuals, moderates the rise in the dependency ratio and, therefore, of fiscal imbalances. These effects are nonlinear and convex: boosting migration has diminishing benefits, while restricting migration would have increasing costs for public finances – these are the costs of building walls.

Specifically, we show that cutting migration flows down to zero increases the fiscal burden of aging, measured by the necessary rebalancing tax increase, by 2.1 percentage points compared to our baseline. This means that shutting down migration would require Euro area countries to, on average, impose an additional tax increase of almost 1 percent of GDP, every year, to deal with the fiscal burden of aging.

Furthermore, we also show that boosting fertility is not an alternative to immigration, as the short-run costs of such a policy – due to a higher population share of infants – exceed the long-run potential benefits of a larger work force.

Our analysis uncovers novel facts informing current policy discussions. Policymakers in Europe considering restrictions on immigration flows from developing countries must take into account that such policies may significantly increase the net tax burden on natives. This is due to the nonlinear effects of immigration on demographic dynamics in aging societies and, consequently, on the fiscal burden of aging.

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The Costs of Building Walls: Immigration and the Fiscal Burden of Aging in Europe

Online Appendix

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A Macroeconomic Framework behind the Accounting Framework

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

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:

$$\Psi_t = \Psi_{\bar{t}} \prod_{j=\bar{t}+1}^{t} \left(1+\gamma_j\right)\left(1+\pi_j\right), \text{ for } t > \bar{t}. \tag{9}$$

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 $g_{t,x}^{sick}$. Old-age individuals 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 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:

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

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 assets.

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:

$$T_t = \sum_i T_t^i = \sum_{x \in X} \begin{bmatrix} \mathcal{T}_x^{IRS} \left(y_{t,x}^l + y_{t,x}^k + g_{t,x}^{unemp} + g_{t,x}^{sick} + g_{t,x}^p \right) \\ + \mathcal{T}^K y_{t,x}^k + \mathcal{T}^{VAT} y_{t,x}^l c_x \\ + \mathcal{T}^{SS} y_{t,x}^l + \mathcal{T}^H h_{t,x} + \mathcal{T}^u \end{bmatrix} P_{t,x} \tag{10}$$

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

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

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:

$$G_t = \sum_i G_t^i = \sum_{x \in X} \begin{bmatrix} g_{t,x}^{unemp} & +g_{t,x}^p & +g_{t,x}^{sick} \\ +g_{t,x}^{health} & +g_{t,x}^{educ} & +g_{t,x}^{PG} \end{bmatrix} P_{t,x} \tag{11}$$

Government budget constraint 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 interest paid on that debt as in Equation (3).

Additionally, the government faces an intertemporal budget constraint (IGBC) as in Equation (7). 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. As in the accounting framework in Section 3 we compute how much must taxes have to increase for Equation (7) to hold.

B Stylized Demographic Model

In this Appendix we build a simple stylized demographic model that explains the demographic result that the immigration size has a nonlinear 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 generation 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.[27] 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 the demography 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:

$$\begin{aligned} P_{o,t} &= (1-\pi_m)P_{o,t-1} + \pi_o\left(P_{a,t-1}^N + P_{a,t-1}^F\right) \\ P_{a,t}^N &= (1-\pi_o)P_{a,t-1}^N + \pi_a P_{y,t-1} \\ P_{a,t}^F &= (1-\pi_o)P_{a,t-1}^F + M \\ P_{y,t} &= (1-\pi_a)P_{y,t-1} + f^N P_{a,t-1}^N + f^F P_{a,t-1}^F. \end{aligned} \tag{12}$$

Each period, the old population faces 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.

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.

[27] Figure 1 illustrates this pattern.

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.[28] 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 empirical relevant case $f^F > f^N$.

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

$$\mathbf{P}_t = A\mathbf{P}_{t-1} + B. \tag{13}$$

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 :

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

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:

$$\mathbf{P}_t = A^t\mathbf{P}_0 + (I-A)^{-1}(I-A^t)B. \tag{14}$$

The stationary population is then given by

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

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

$$\mathbf{P} = M \times \frac{1}{\pi_o - f} \times \begin{bmatrix} \frac{\pi_o}{\pi_m} \\ 1 \\ \frac{f}{\pi_a} \end{bmatrix}. \tag{15}$$

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.[29] 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" (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.[30] 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 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.

The Case 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:

$$\mathbf{P}_t = A\mathbf{P}_{t-1} + B. \tag{16}$$

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 :

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

[30] In the demography 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.

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

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:

$$\mathbf{P} = (I-A)^{-1}B$$

$$\mathbf{P} = M \times \begin{bmatrix} \frac{1}{\pi_{\text{O}} - f^N} \times \frac{\pi_{\text{O}} + f^F - f^N}{\pi_m} \\ \frac{1}{\pi_{\text{O}} - f^N} \times \frac{f^F}{\pi_{\text{O}}} \\ \frac{1}{\pi_{\text{O}}} \\ \frac{1}{\pi_{\text{O}} - f^N} \times \frac{f^F}{\pi_a} \end{bmatrix} \quad (17)$$

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:

$$\frac{\pi_a\pi_m\left(f^F - f^N + \pi_o\right)}{\pi_{\text{O}}\left[f^F\pi_m + \pi_a(f^F - f^N + \pi_o)\right]}$$

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 (15), the first case above. If M is set to zero, we are in the extinction case.

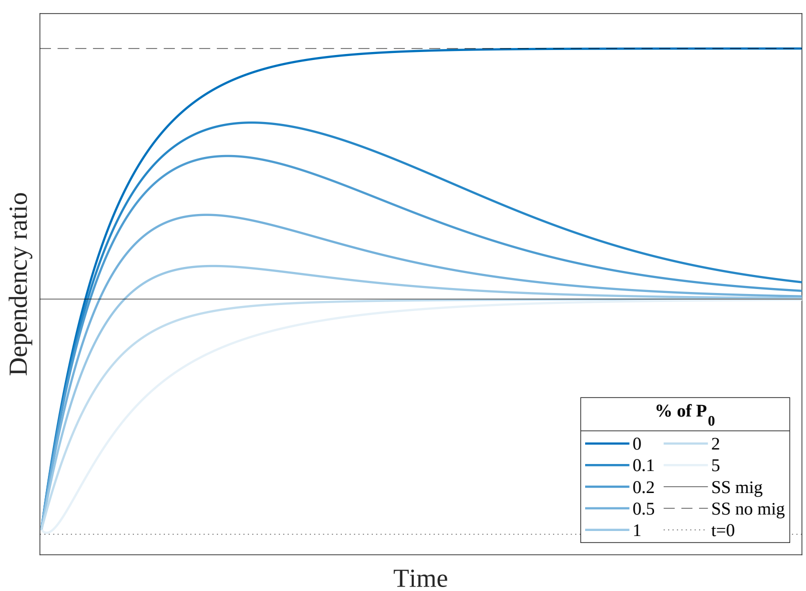
Importantly for our purposes, there is one single long run dependency ratio for any $M > 0$, and another, higher, in the case of $M = 0$.

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.[31] 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 5% of the initial population (0, 0.1%, 0.2%, 0.5%, 1%, 2%, and 5%). Figure 8 plots the value of the dependency ratio along the transition for the different scenarios.

Figure 8: 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.

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

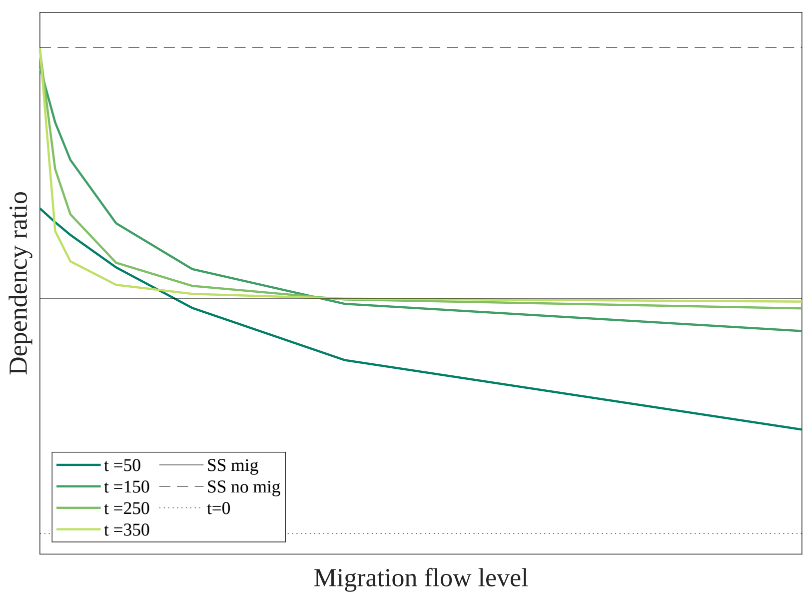
The model simulation produces an age distribution throughout the transition, demonstrating a convergence pattern to the stationary dependency ratio value of 1.17 for all positive values of immigration. However, this value is only attained after several hundred periods. This illustrates that the size 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 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 nonlinear 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.

Figure 9: 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.

To illustrate this, we depict in Figure 9 the connection between migration flow levels and the dependency ratio for four 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. The demographic patterns generated in this simple model are the same as the ones of a more complex model as the one that we use in the main text. In fact, the convex relationship between migration and the primary deficit shown in Figure **??** come from the convex relationship between migration and the dependency ratio that we show here, as we explained before.

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.

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 over time to compute the counterfactual government budget. Therefore, the results may 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, there are three solutions that the literature has been using.

A first approach is choosing a base year where GDP is close to the potential GDP. This approach is used in Franco et al. (2020) where 2017 is picked as the base year which, according to the AMECO database, is the year in the last decade where the output gap was closer to 0 in Portugal (the country the authors study). A second approach that is used in 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 for the base year.

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 cyclical-neutral fiscal aggregates. This is similar to what is done in Bonin et al. (2014) based on the work by Girouard and André (2006). In order to compute the cyclical-neutral item i ,$\left(T^i_{\bar{t}}\right)^*$, consider the following relationship:

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

where $T_{\bar{t}}^{i}$ 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 cyclical-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. The other budget items are less subject to business cycle fluctuations. In Table 4 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.

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

$$\theta_{\tau}^{AGK} = \frac{\sum_{s=0}^{J} \sum_{i} \sum_{a=s}^{J} \sum_{g,k,c} D^{s} \left(g_{\bar{t},a,g,k,c}^{i} - \tau_{\bar{t},a,g,k,c}^{i}\right) P_{\bar{t}+s,a,g,k,c} + \sum_{s=1}^{\infty} \sum_{i} \sum_{a=0}^{min\{s,J\}} \sum_{g,k,c} D^{s} g_{\bar{t},a,g,k,c}^{i} P_{\bar{t}+s,a,g,k,c} + B_{\bar{t}-1}}{\sum_{s=1}^{\infty} \sum_{i} \sum_{a=0}^{min\{s,J\}} \sum_{g,k,c} D^{s} \tau_{\bar{t},a,g,k,c}^{i} P_{\bar{t}+s,a,g,k,c}} - 1.$$

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:

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

C.3 Estimation of the Demographic 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. 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 4. 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.

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 age, gender and skill compositions.

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). Figures 12 – 21 show the estimated demographic profiles by country for each budget item.

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. (2022b). 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). We use the EU average for all countries.

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 due 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. After 2100 we assume a fully stationary population.

Fertility and Mortality The mortality rate used is the same across skill level and country of birth and only differs by age and gender.[32] 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 until 2100, for all EA countries. 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.

Skill/Education We also split the population by skill level. Data on skill and country of birth compositions by age group is available for 2019. We build 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 assumptions for the projection: (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 working-age population is smaller than in the base period and, conversely, the medium and high-skill working-age population share is higher. Our skill distribution projection can be seen as a conservative scenario since most peripheral EU countries observe an increasing share of population studying more. 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.

[32] 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.

D Additional Data Sources Details

D.1 Microdata Sources

Table 3: Microdata Sources

Tax/benefit	Source	Micro data variables used for distribution
PIT	EU-SILC	Income taxes (HY140G)
Property tax	EU-SILC	Taxes on wealth (HY120G)
VAT	HBS - 2015 wave	Total consumption (EUR_HE00)
CIT	HFCS - wave 3	Business wealth (da1140 + da2104 + da2105)
Social Contributions	EU-SILC	Labor income (PY010G)
Disability pension	EU-SILC	Disability benefits (PY130G)
Old-age pension	EU-SILC	Old age benefits (PY100G)
Sickness allowance	EU-SILC	Sickness benefits (PY120G)
Survivor pension	EU-SILC	Survivor benefits (PY110G)
Unemployment subsidy	EU-SILC	Unemployment benefits (PY090G)

D.2 Macrodata Sources

Table 4: Macrodata Sources

Aggregate	Variable	Observations
	Demographic data (from Eurostat)	
Population projections	proj_19n	
	Fiscal data (from Eurostat - gov_10a_ggfa data-set)	
Personal income	D51A	
Property	D29A	
Value-added	D211	
Corporate income	D51B	
SS contributions	D611+D612+ D613	
Disability pension	GF1001	Split according to the public accounting
Sickness allowance	GF1001	Split according to the public accounting
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 Gov. 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.[33] Table 5 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 5: Imbalance Metrics under Different Macroeconomic Assumptions

Scenario	θ_τ	θ_τ^{AGK}	IBG
Baseline	12.7%	52.6%	3.15
$\gamma = 0$	12.5%	60.1%	2.55
$\gamma = r$	13.1%	37.6%	5.71

Note: The value of θ_τ reported corresponds to the weighted average of the rebalancing tax increase of each country computed according to Equation 8, 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.

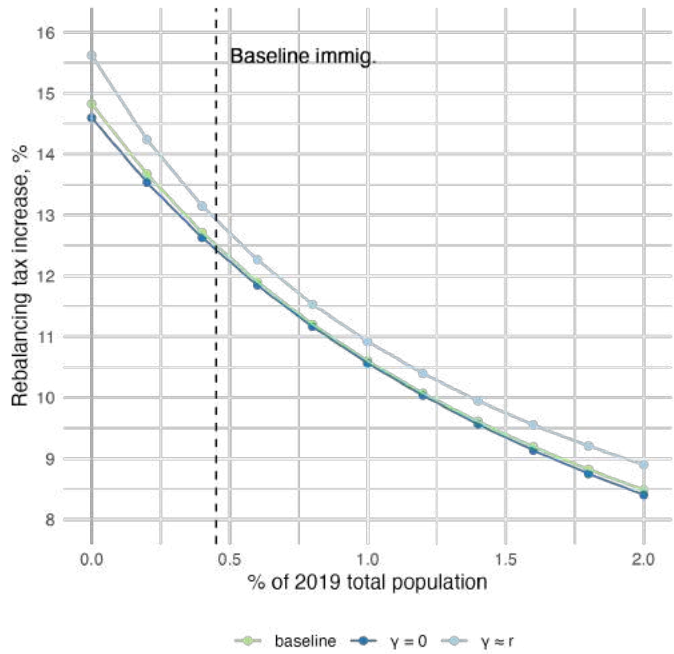
To see that the macroeconomic hypotheses do not play a role in the increasing costs on public finances of reducing migration, we also recompute the frontier between the rebalancing tax increase and the immigration level. It follows from the fact that D has a minimal influence on θ_τ that it also does not affect the convex relationship between migration and the tax adjustment. In Figure 10 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

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

Figure 10: Frontier between the Level of Net Migration and the Imbalance Factor Implied for Different Values of the Discount Factor, D



Note: The figure shows the weighted average θ_τ across countries using the 2019 potential GDP as weights, for the different net migration scenarios. θ_τ is computed according to equation (8), under different values for the discount factor, D. The dashed line is the baseline net migration value.

fertility rate of residents born in non-EU countries is almost double that of the native population. We perform sensitivity exercises to check to what extent the impact of migration relies on the fertility of non-EU immigrants. We consider two cases:

1. High Fertility: 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 Fertility: 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 6 shows this metric together with the θ_τ^{AGK} 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.

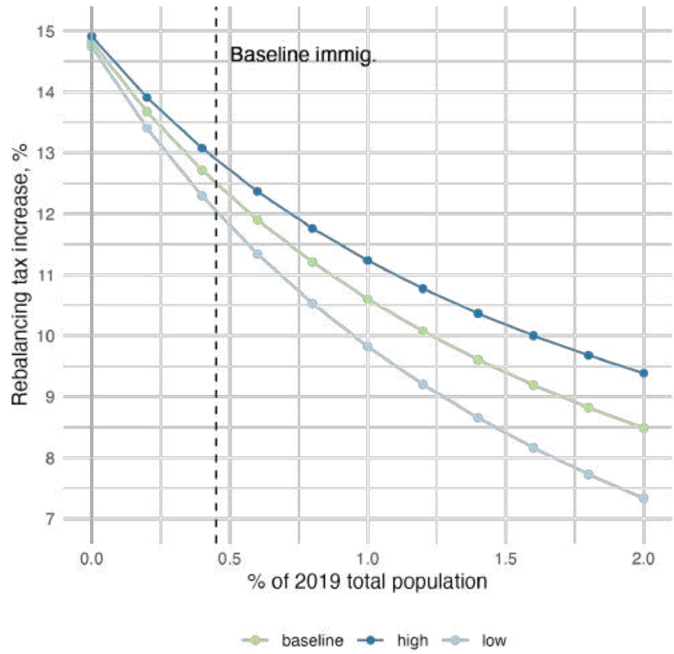
Table 6: Imbalance Metrics under Different Non-EU Immigrant Fertility Rates

Scenario	θ_τ	θ_τ^{AKG}	IBG
Baseline	12.7%	52.6%	3.15
High fertility	12.9%	51.5%	3.28
Low fertility	12.3%	49.6%	3.07

Note: The value of θ_τ reported corresponds to the weighted average of the rebalancing tax increase of each country computed according to Equation 8, 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 then, change the net migration scenario for the two additional fertility hypotheses. Figure 11 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. Notoriously, the convexity of the frontier is higher for the cases when the fertility rate of immigrants is smaller. This happens because the education costs in the short run get amplified when there are more immigrants flowing into the EA.

Figure 11: Frontier between the Level of Immigration and the Imbalance Factor for Different Immigrants' Fertility Hypotheses.

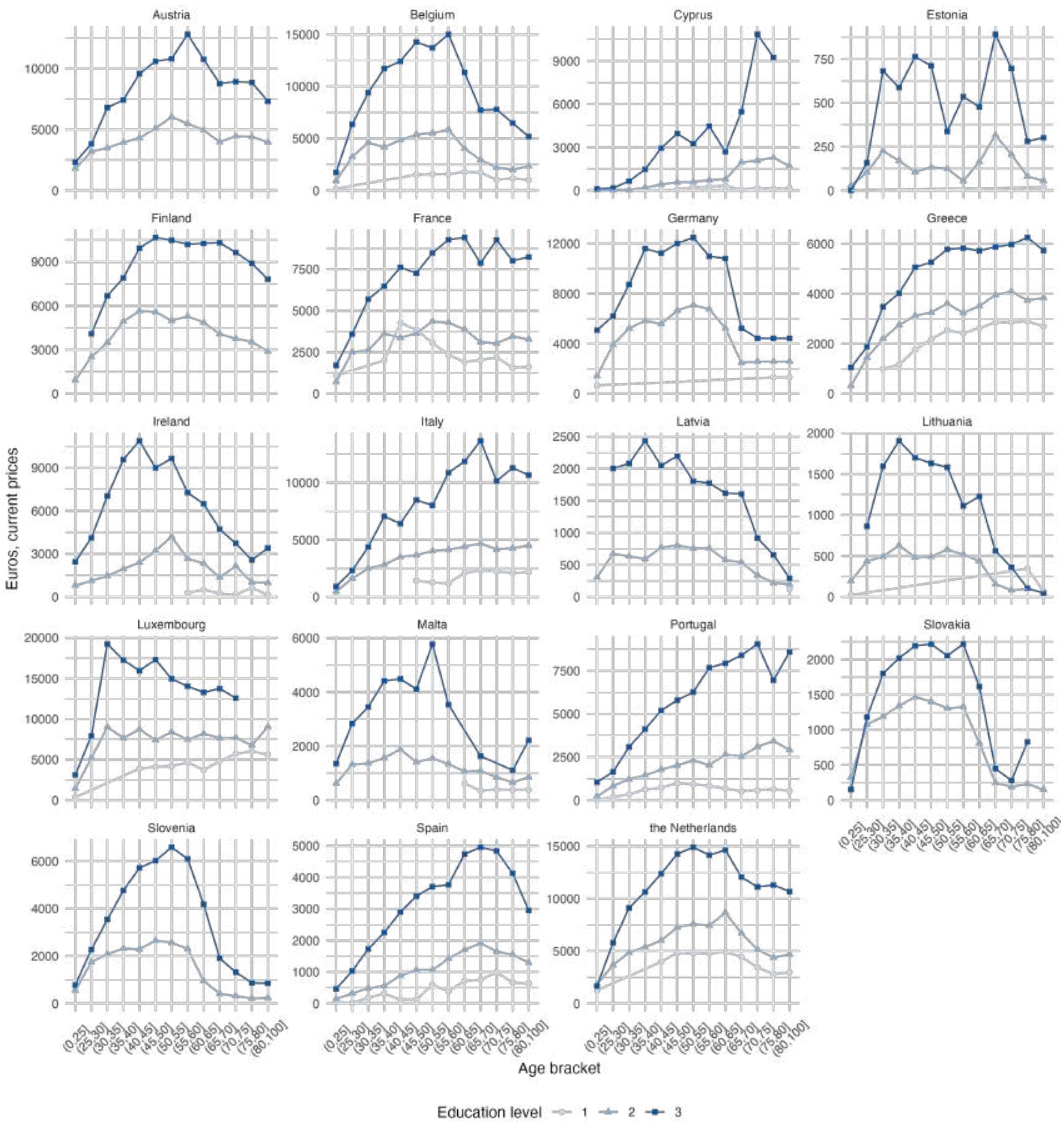


Note: The figure shows the weighted average θ_τ across countries using the 2019 potential GDP as weights, for the different net migration scenarios. θ_τ is computed according to equation (8), scenarios of the non-EU born fertility rates. The dashed line is the baseline net migration value.

F Additional Figures

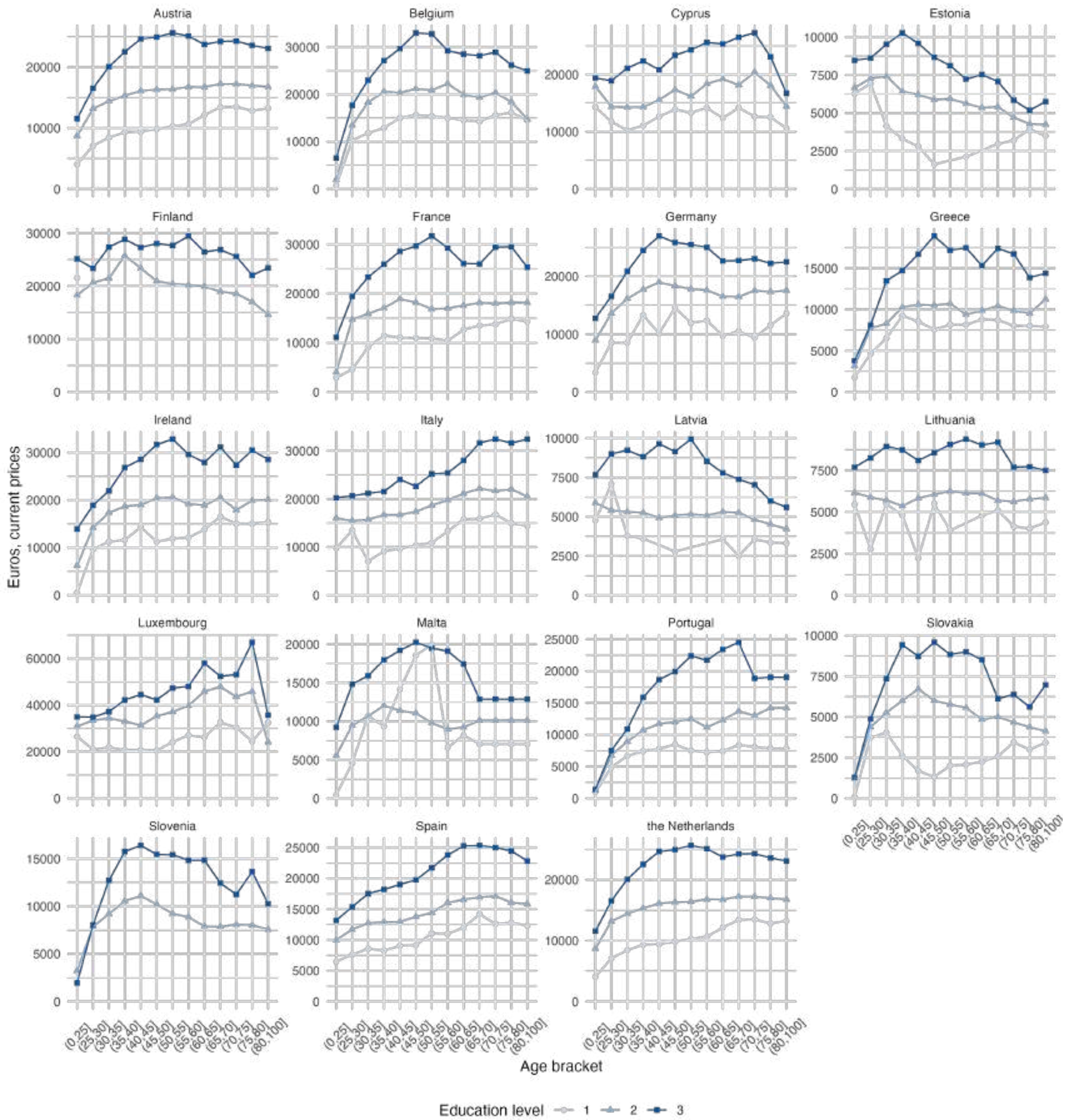
This Appendix provides demographic profiles of several microeconomic variables estimated from different survey data sources, as described in Table 3, for each of the countries in our sample. Generally, we show here the average value for each age-bracket and education level. In some cases, where the sample was too thin, we did not break it down by education level. In either case, for our projections we further break down samples by gender, not shown here for clarity. Also, often, sample sizes of the lowest education level are very small or inexistent (e.g. in Finland almost no individuals attained less than secondary education) and therefore omitted.

Figure 12: Demographic Profiles of Income Tax Payments



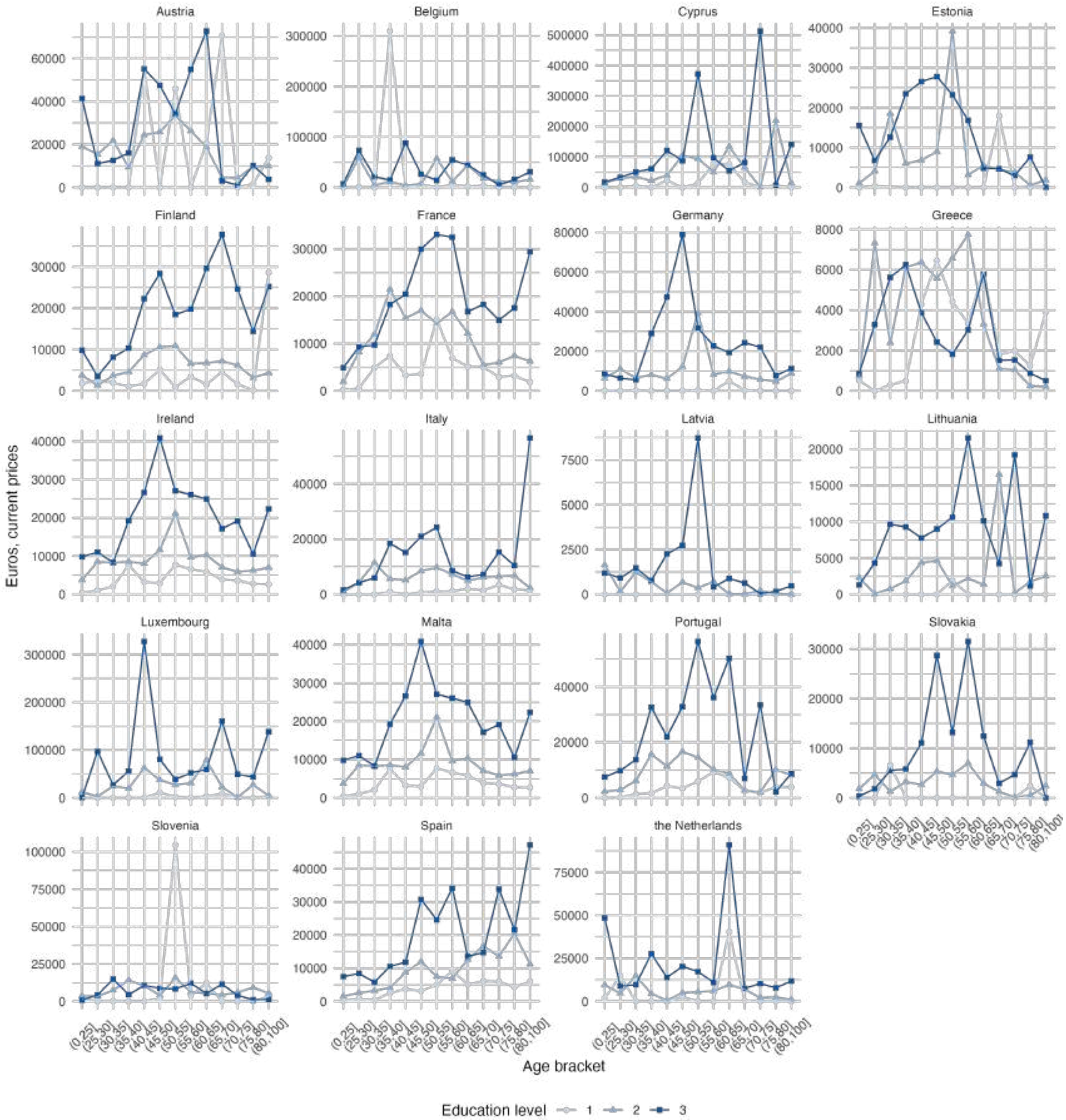
Note: Data from EU-SILC, 2019 wave on household-level income tax payments, assigned to household members in proportion to their respective share in the total household income. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 13: Demographic Profiles of Consumption



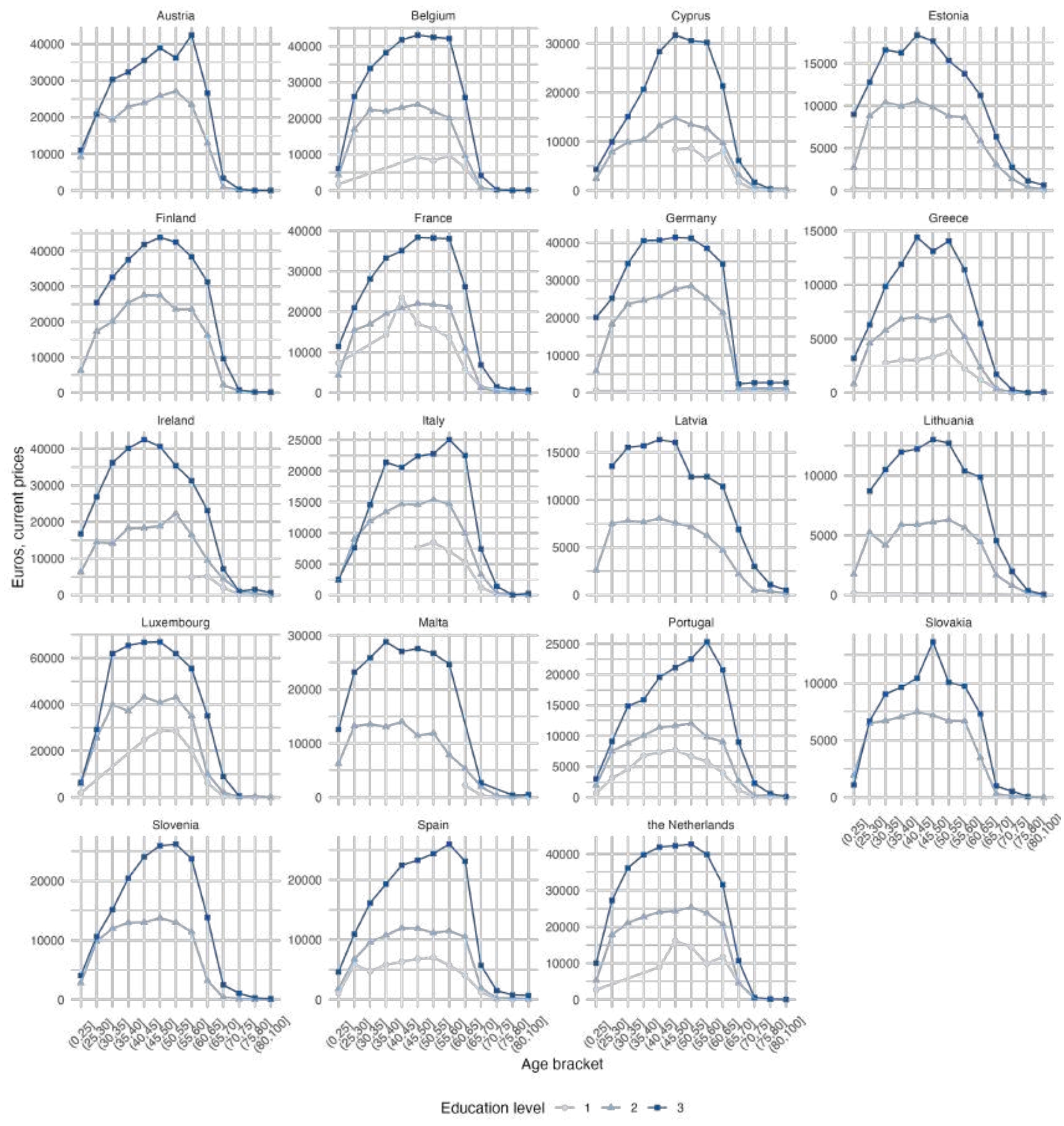
Note: Data from HBS, 2015 wave on household-level total consumption spending, assigned to household members in proportion to their respective share in the total household income. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 14: Demographic Profiles of Business Wealth



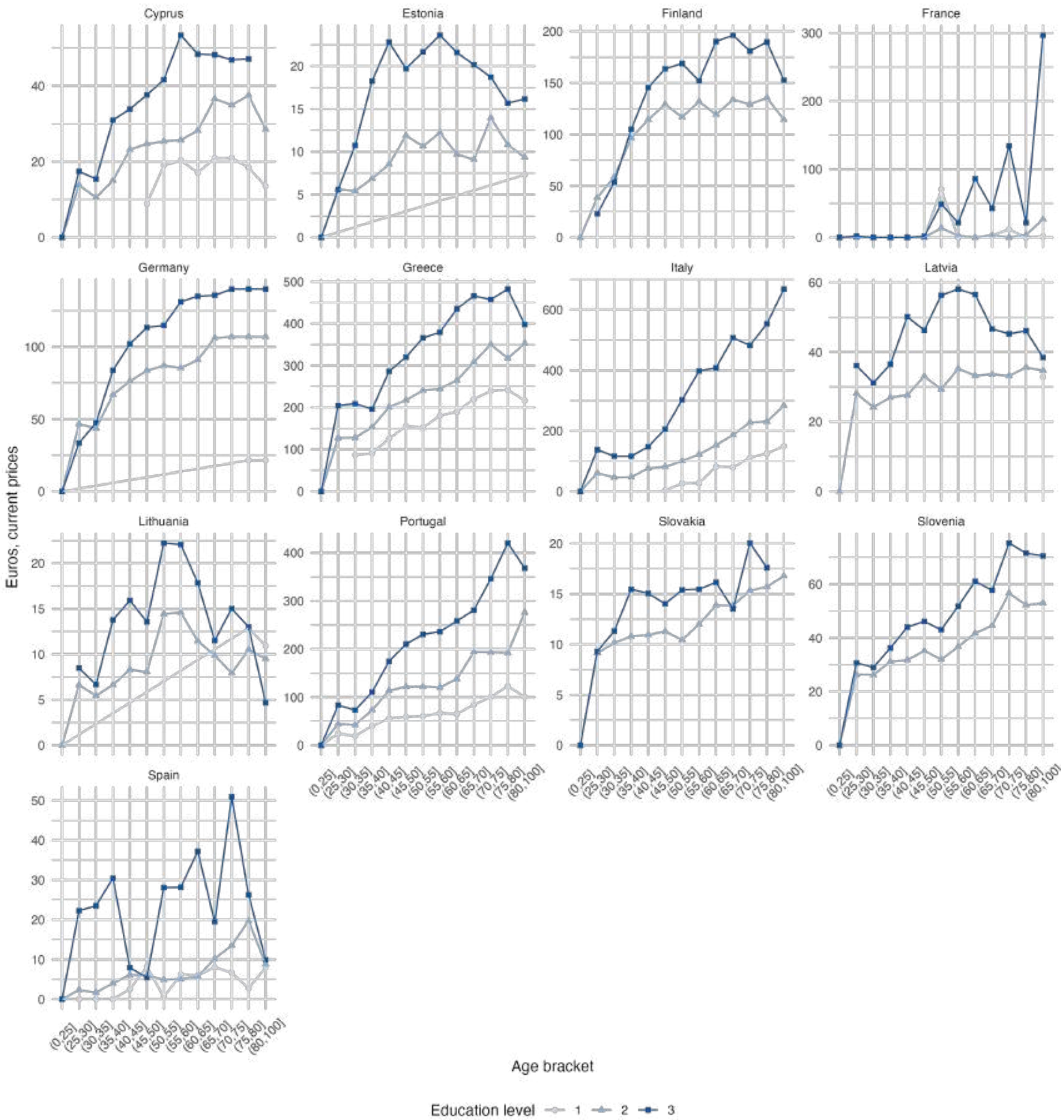
Note: Data from HFCS, 2017 wave on household-level business wealth holdings, equally split between adult household members. Data is plotted for each country, age-bracket and skill level.

Figure 15: Demographic Profiles of Labor Income



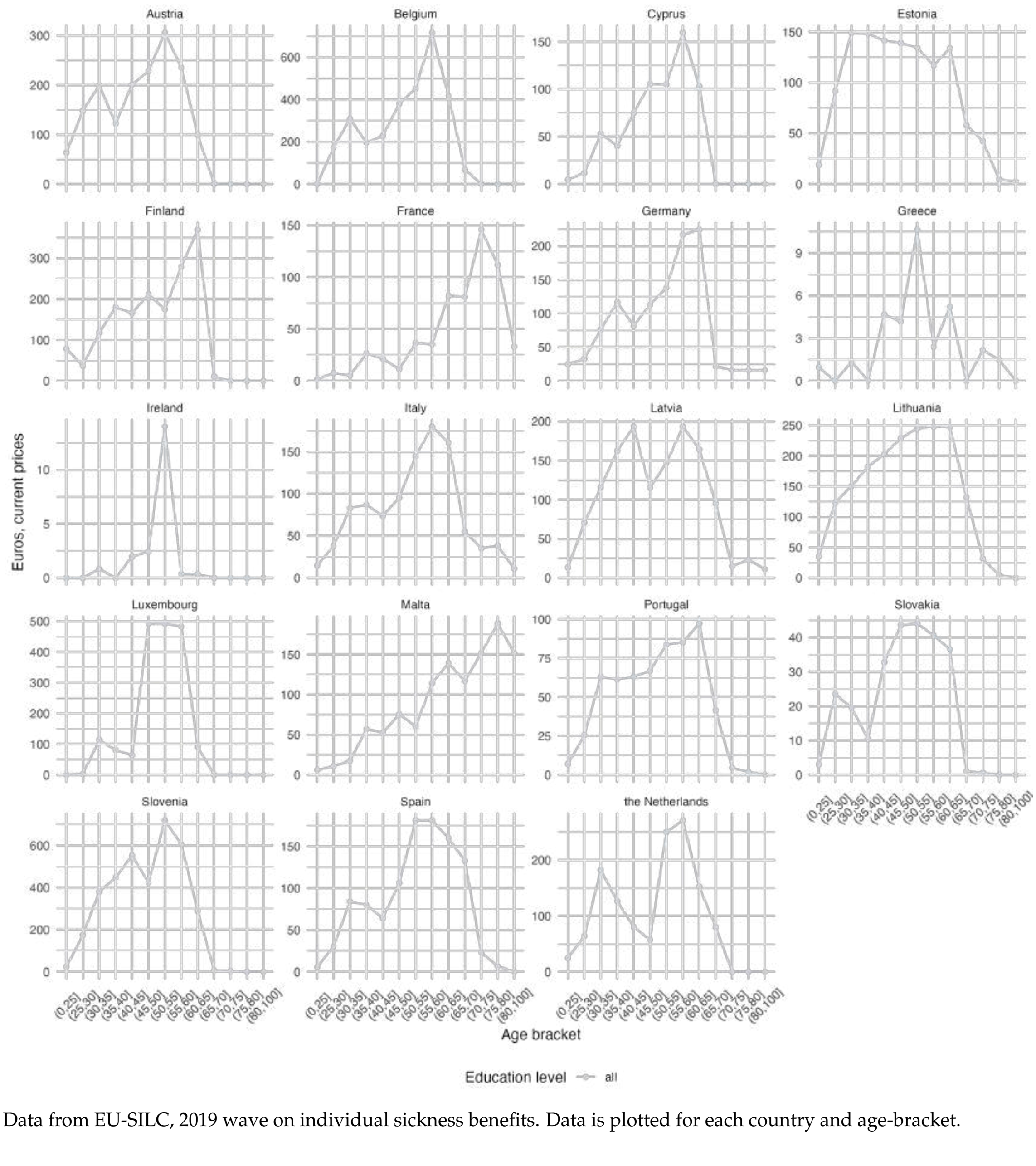
Note: Data from EU-SILC, 2019 wave on individual labor income. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 16: Demographic Profiles of Wealth Taxes



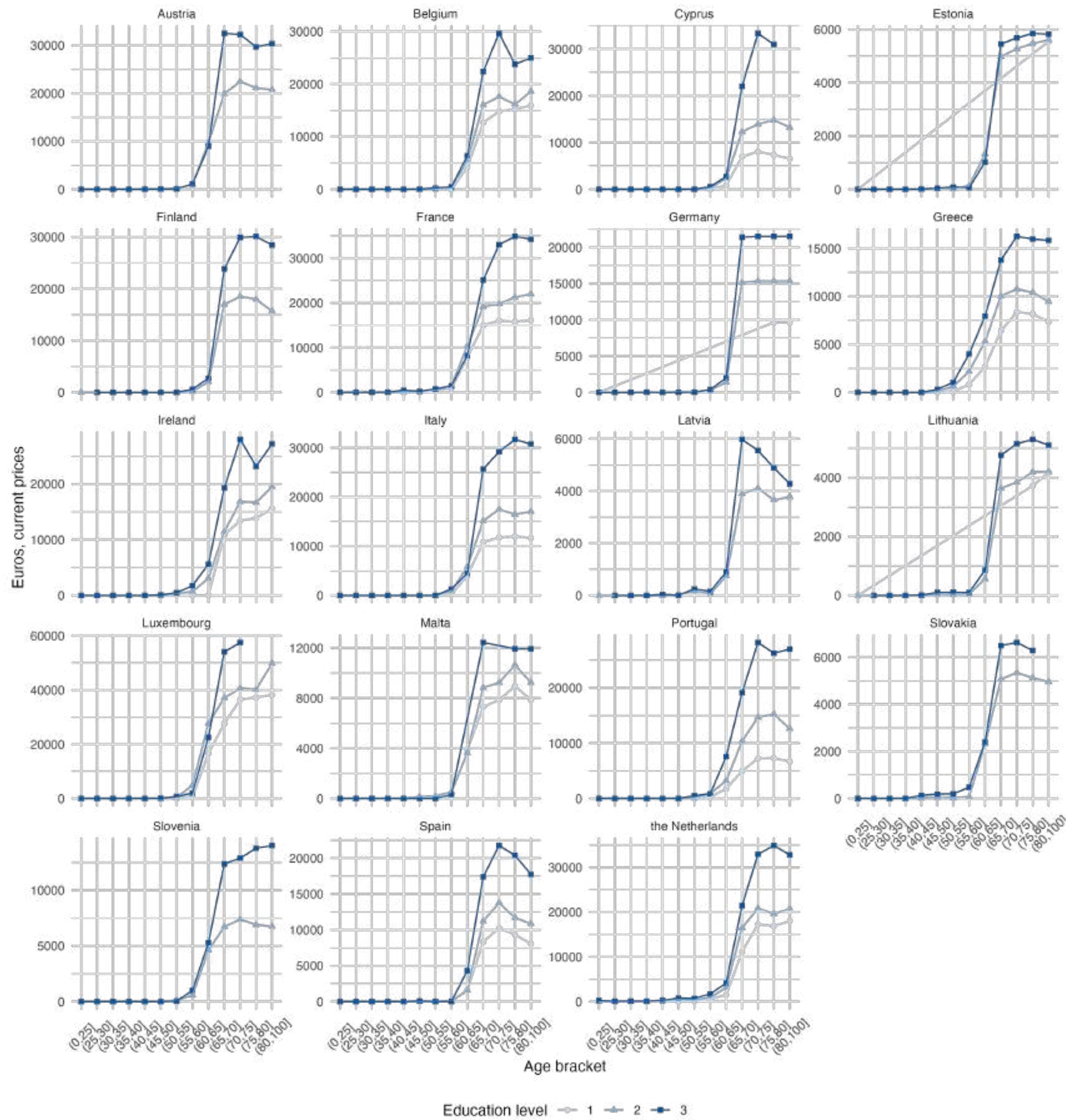
Note: Data from EU-SILC, 2019 wave on household-level wealth tax payments, equally split between adult household members. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 17: Age Profiles of Sickness Allowance



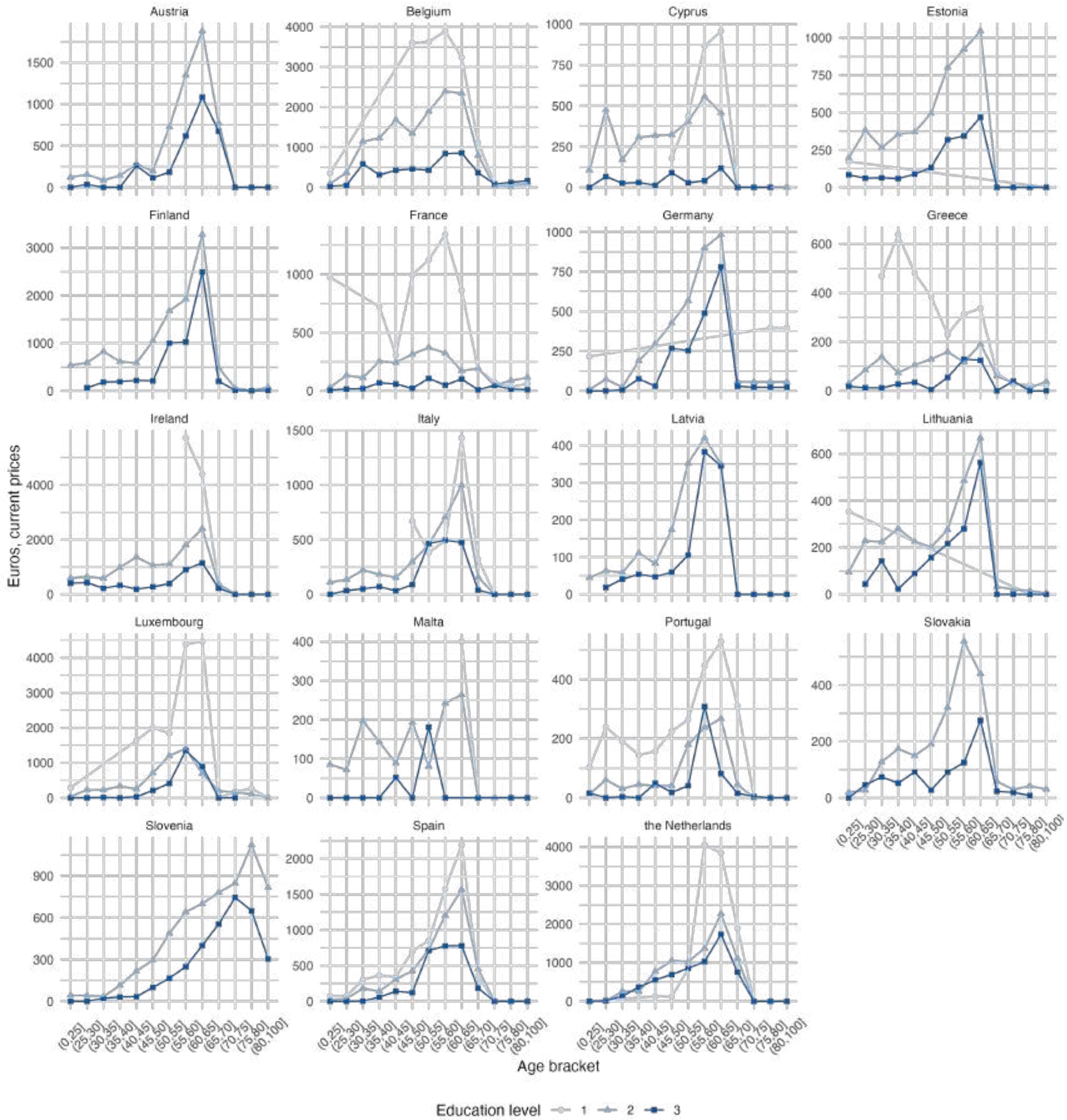
Note: Data from EU-SILC, 2019 wave on individual sickness benefits. Data is plotted for each country and age-bracket.

Figure 18: Demographic Profiles of Old-Age Pension



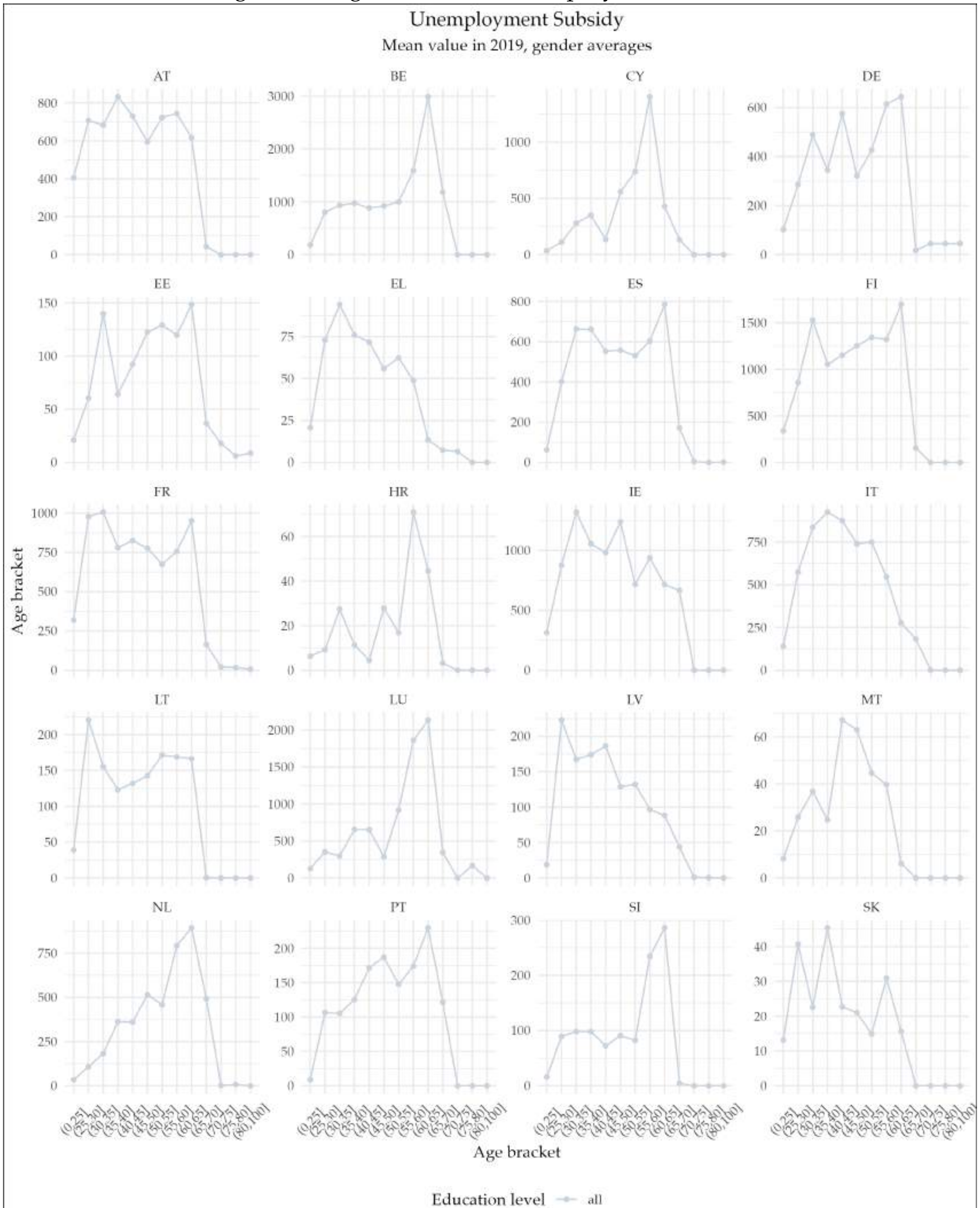
Note: Data from EU-SILC, 2019 wave on individual old age benefits. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 19: Demographic Profiles of Disability Benefits



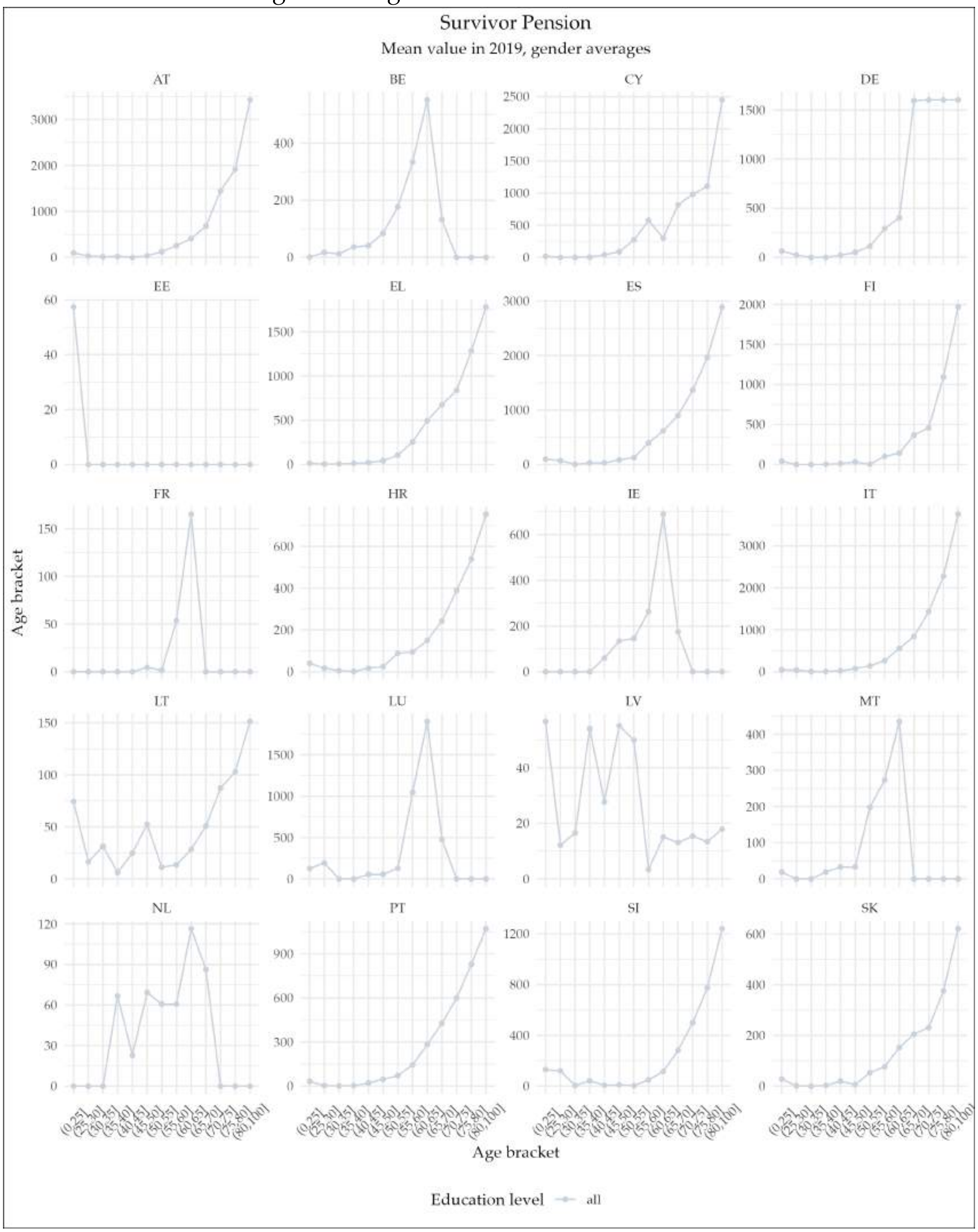
Note: Data from EU-SILC, 2019 wave on individual disability benefits. Some data points may be omitted due to confidentiality restrictions (cell size below 50 observations). Data is plotted for each country, age-bracket and skill level.

Figure 20: Age Profiles of Unemployment Benefits



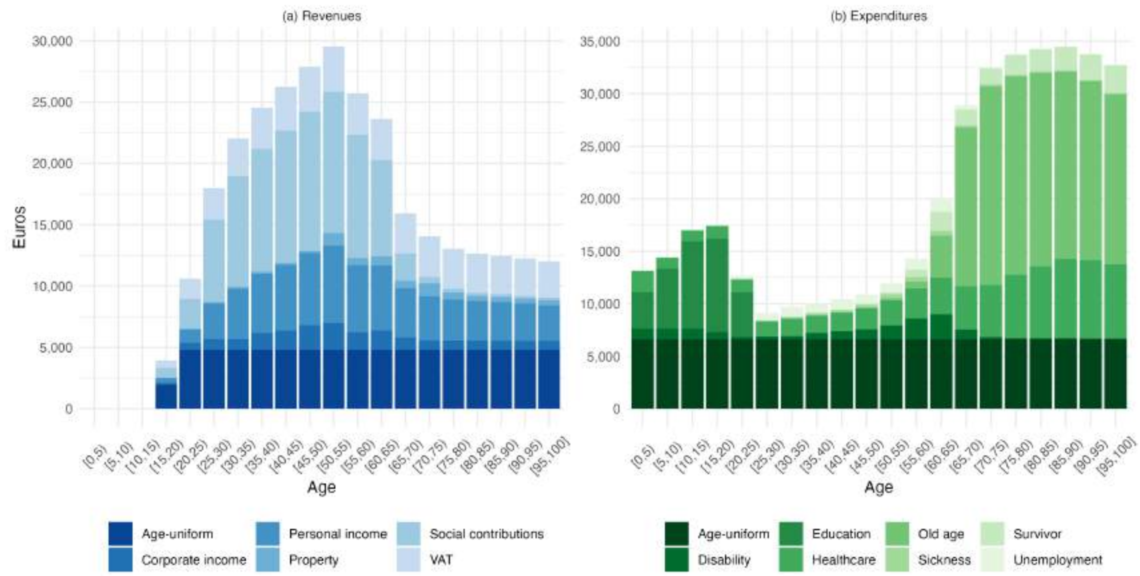
Note: Data from EU-SILC, 2019 wave on individual unemployment benefits. Data is plotted for each country and age-bracket.

Figure 21: Age Profiles of Survivor Pension



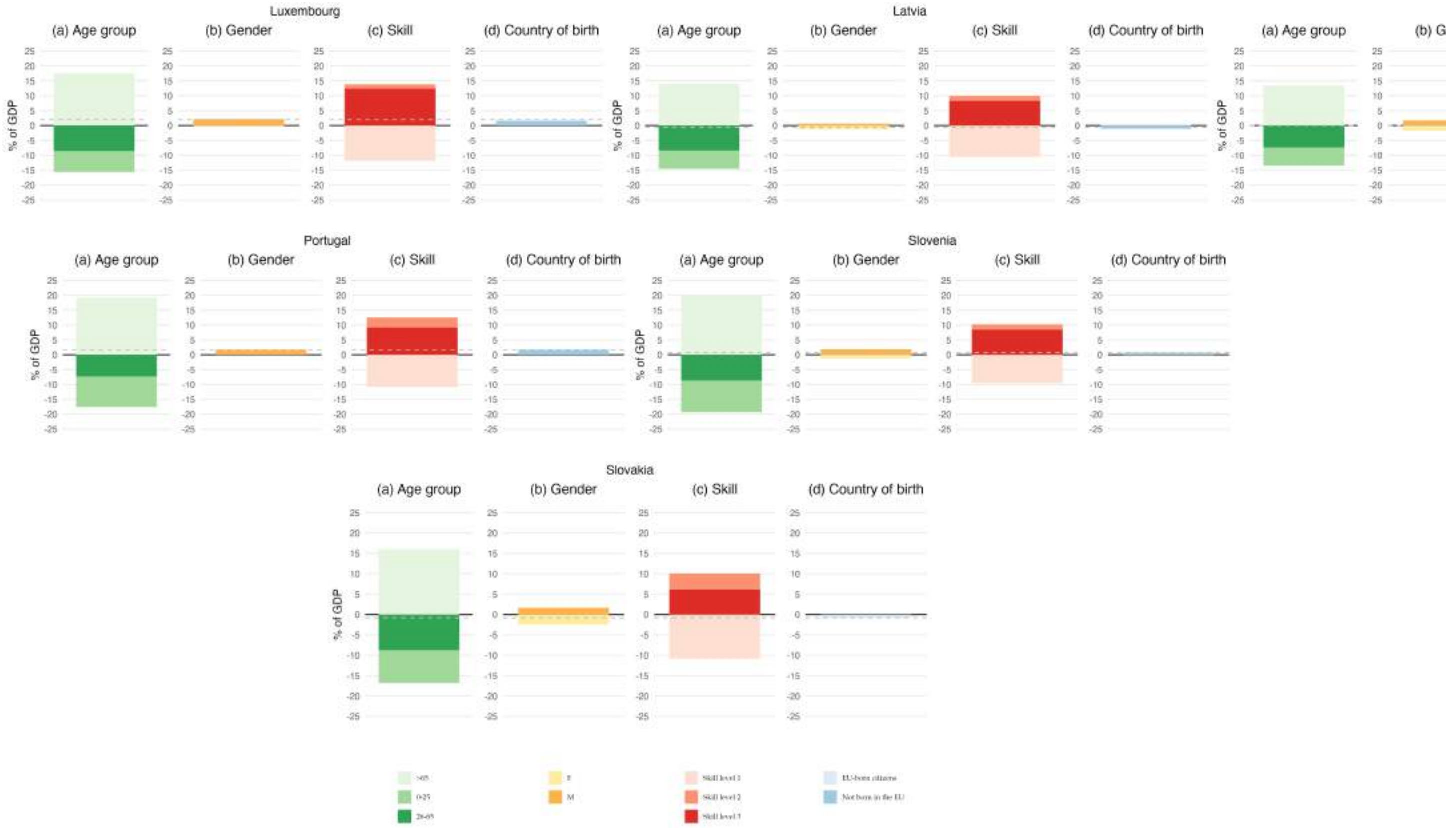
Note: Data from EU-SILC, 2019 wave on individual survivor benefits. Data is plotted for each country and age-bracket.

Figure 22: Age Profiles of Net Taxes and their Composition



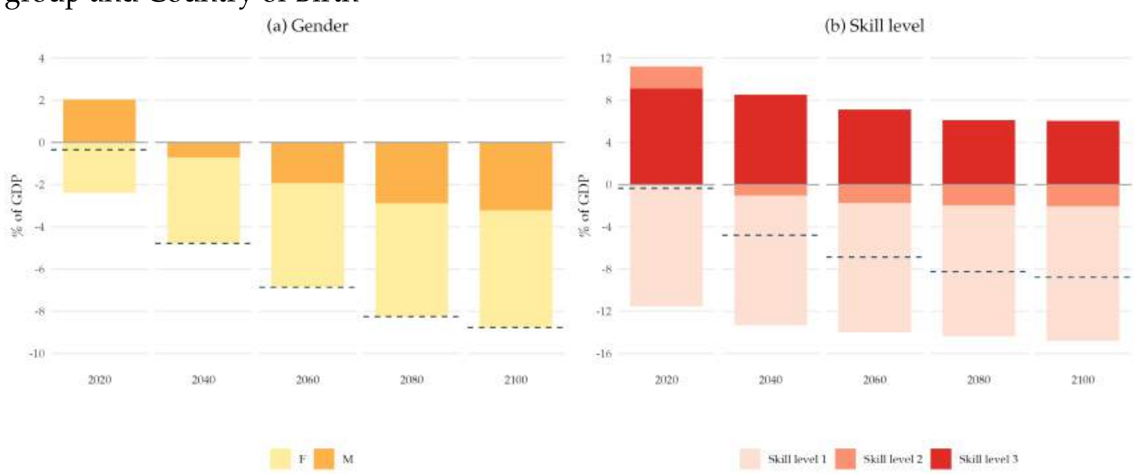
Note: The Figure shows means for five-year age brackets of per capita revenue (left panel) and spending (right panel), for the average across EA countries weighted by their respective 2019 potential GDP. Unlike the preceding figures which directly show results from survey data, these age profiles have been rescaled to be consistent with the aggregates for each budget item.

Figure 23: 2019 Primary Balance Decomposition by Demographic Characteristics by country



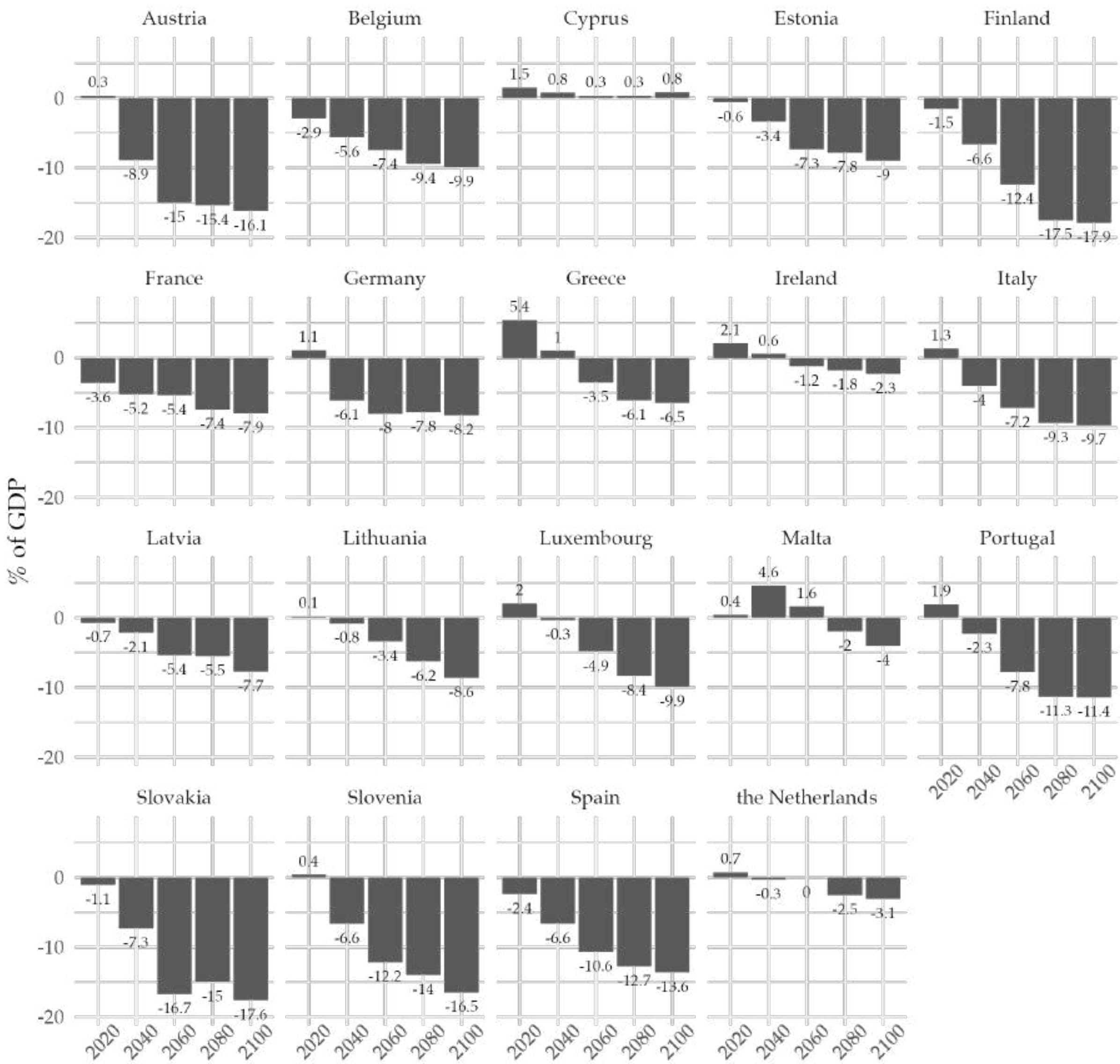
Note: This corresponds to the sum of revenues net of benefits attributable to agents with a given demographic characteristic in percentage of the 2019 potential GDP. The dashed line corresponds to the value of the primary balance in 2019. All values are in percentage of the potential GDP.

Figure 24: 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 25: 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.