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

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Abstract

In low-fertility societies with regular immigration inflows of young workers, reducing immigration disproportionately raises dependency ratios as native populations shrink. This creates a convex policy frontier: restricting migration raises fiscal costs at an increasing rate. We quantify this mechanism using a population model combined with novel estimates of immigrants' fiscal contributions in Euro area countries. Eliminating immigration raises the fiscal burden of aging by 16%, while doubling inflows reduces it by only 9%. The convexity generates large cross-country differences in fiscal gains from immigration, complicating common European policy design. Increasing fertility does not provide comparable relief.

JEL codes: E62; F22; H55; J11

Keywords: Public Finances; Migration; Aging; Europe

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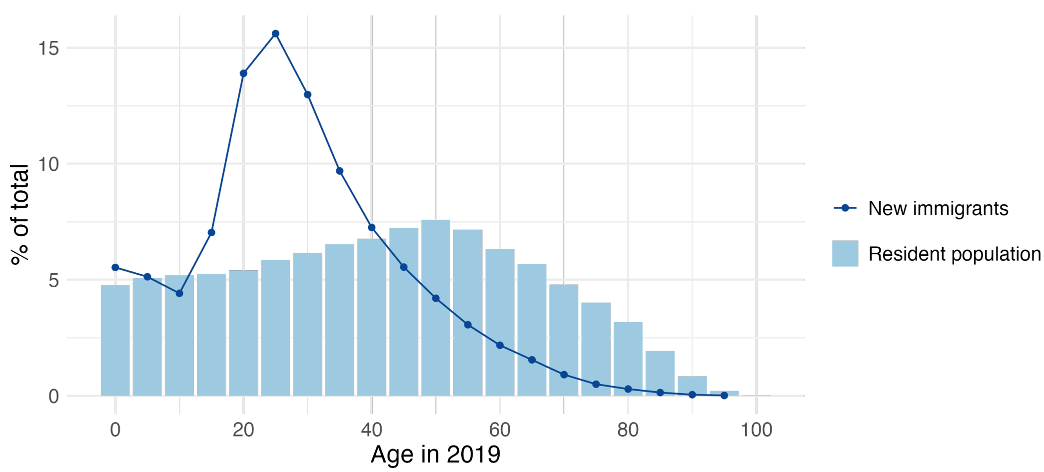
1 Introduction

Aging poses a major challenge for developed economies, particularly in Europe. Over the last decades, the population share of working-age individuals has been shrinking, as fertility rates have fallen and life expectancy continues to rise. In Europe, the old-age-dependency ratio (the ratio of 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 older people.

Immigration is frequently discussed 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, shown by the solid line, are concentrated in the working-age group, in contrast to the resident population stock, represented by the bars. As immigrants are relatively young, they can slow population aging and ease the pressure on public finances.

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



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

Despite these potential benefits of immigration, political platforms that portray migration as a problem are gaining traction. Currently, European countries are discussing policies to contain or even cut down immigration from the developing world. In this paper, we assess whether such policies can aggravate the fiscal burden of aging in Europe. Specifically, we investigate how restricting or expanding net migration inflows from developing countries affects demographic dynamics and, in that way, public finances in Europe. We proceed in three steps.

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

First, we build a population projection model, featuring constant net migration inflows, and then analyze the model's dynamics under different scenarios for the size of these inflows.[2] Our baseline projection shows an increase in the share of non-EU-born population and their descendants. By 2050, the share of non-EU-born population and their descendants will be 25 percent. By 2100, it will be at 50 percent. This implies that aggregate population dynamics will increasingly depend on immigrants and their descendants. We show that restricting immigration leads to higher future dependency ratios, which negatively impact public finances. We refer to these negative impacts as the "costs of building walls". Importantly, we show that this relationship is non-linear: each additional restriction on immigration has an increasingly large effect on the dependency ratio.

Second, we look at the current contribution of immigration 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. With these profiles we find that the current net contributions of the non-EU-born population are positive, around 0.57 percent of the potential GDP. Contrarily, the EU-born population has net contributions to the budget of -0.62 percent of the potential GDP. We show that this difference is due to a younger age composition of the non-EU-born population, despite the EU-born population having higher net contribution per capita, leading to positive primary balances.

Third, we quantify the implications of changing the immigration flow for the fiscal burden of aging. For that, we combine the population projections under different net migration flow scenarios with the demographic profiles that we keep fixed. This way, we obtain different counterfactual government budget series. We measure accumulated fiscal imbalances in the different scenarios, which we summarize by calculating the tax increase required to ensure the government budget is sustainable in the long-run. 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 the baseline net migration yearly flow of 0.4 percent of the population (1.33 million people), European countries would have to permanently increase the tax burden by 14 percent, on average, to ensure fiscal sustainability. This means an additional 5.9 percent of GDP in revenues each year, which compares with the current 42 percent of GDP collected in taxes and social contributions. Cutting this flow down to zero increases the fiscal burden of aging, measured by the rebalancing tax increase, to 16.3 percent, i.e., 2.3 percentage points higher than in the baseline. This means shutting down migration would demand an additional tax burden of 1 percent of GDP to ensure public finance sustainability. These numbers rely on sustaining the net migration inflow of 2019 in the future, both in its overall size, and age-education structure, mostly composed of younger and lower-qualified individuals.

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 1.4 percentage

[2] A constant net migration flow is the standard assumption in population projections. External factors, linked to conditions in origin countries, are the most important drivers of this inflow and are hard to predict. All our results hold qualitatively regardless of fluctuations in immigration flows, as long as they remain larger than the decline of the native population.

points. The effects of increasing net migration flows are concave: 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 decreasing, the population share of immigrants and their descendants is increasing over time. If we intensify the flow of migrants, this accelerates the 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 concave effects of immigration on public finances sustainability.

Furthermore, we also 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), the rebalancing tax increase slightly improves by 0.7 percentage points. This contrasts with the 2.3 percentage points reduction obtained by maintaining the migration levels of 2019, compared to the same zero migration scenario. The short-run costs of a higher share of children, which are net beneficiaries from the government budget, outweigh the long-run benefits of a larger working-age population, which only come much later. In our projections, increasing fertility leads to higher budget deficits until close to the year 2060, vis-à-vis the scenario with baseline fertility and zero migration.

Our main findings are robust to alternative assumptions regarding immigrant fertility, educational composition, real productivity growth, and interest rates. The nonlinearity we highlight arises from demographic dynamics that apply broadly whenever native fertility falls below replacement while there is a sustained inflow of working-age migrants. As such, the mechanism we identify is not specific to Europe but extends to other low-fertility economies, including Australia, Canada, Japan, Korea, the United Kingdom, and the United States. Specifically, the United States has seen large inflows of young, mostly low-qualified immigrant workers which, are similar to those who have recently immigrated into the EU in similarly large numbers.[3] Moreover, the nonlinearity we identify implies that the fiscal impact of immigration is potentially even larger in countries such as Japan and Korea, where immigration flows remain small relative to the scale of demographic aging..

Finally, we also provide estimates of the tax increases required to restore public finance sustainability for each country of the EA. We show a large heterogeneity across European countries with respect to the necessary tax increase to rebalancing public finances. The differences across countries depend on the public debt level, the primary balance, and demographic factors. In particular, due to the decreasing returns of immigration to public finances, the potential of migration to mitigate the fiscal burden of aging differs significantly across EA member states. In some countries,

[3]The United States are also characterized by large internal migration flows. This does not affect the applicability of our results as we focus on migration into the EU from developing countries.

migration substantially reduces the fiscal pressure, while in others, the contribution of migration is relatively small. These findings have important implications for policymakers, particularly in the context of designing a common EU migration policy. The heterogeneous impact of migration on the fiscal sustainability of individual member states suggests a one-size-fits-all approach may not be optimal, and will be difficult for member states to agree on.

Related Literature and Contribution This paper advances the literature on the fiscal effects of immigration by showing that, in any aging population with low fertility, expanding immigration flows has a positive, non-linear effect on public finances operating through demographic dynamics. These insights are new to the literature on the contribution of immigrants to the government budget in advanced countries (Auerbach and Oreopoulos, 1999; Lee and Miller, 2000; Bonin et al., 2000; Storesletten, 2000; Storesletten, 2003; see Rowthorn, 2008 for a review or Hansen et al., 2017 for a more recent application). The results of these papers concurred that immigration mitigates the fiscal burden of aging, but their conclusions were conditional on particular characteristics of immigration flows, such as their skill composition.

Our results, in contrast, generally apply to any population where fertility is below replacement and there is a regular inflow of immigrants, which is the case of almost all advanced economies. We show that, in any context where this applies, expanding immigration will have positive, but decreasing, effects on fiscal sustainability. While the demography literature has examined the dynamics of the age structure of population in this setting (see Espenshade et al., 1982, or Schmertmann, 1992 for an overview), the implications for public finances had not been studied. These results are relevant not only for Europe, studied in our empirical application, but across all advanced economies which face similar demographic dynamics, including the United States.

A different strand of the literature on the fiscal effects of immigration focuses on the cross-section of immigrants' current contributions to the government budget (Dustmann and Frattini, 2014 or Preston, 2014). Our findings indicate that, within the EU, the current contribution of immigrants to the primary balance is modest (in line with the results in recent exercises by Christl et al., 2022 and Fiorio et al., 2023). However, we show that the impact of immigration on the fiscal burden of aging is substantial, by considering migrants' lifetime contributions and the dynamic effects of a regular immigrant inflow. Looking only at current contributions does not capture these population dynamics. Predicting the effects of policies to expand or restrict migration flows requires such an analysis, which we provide.

Recently, better data has allowed for studies exploring "indirect" effects of immigration on public finances, in particular through the labor market.[4] Notably, Colas and Sachs (2024) show that low-skilled immigrants indirectly benefit public finances through their effect on resident wages and labor supply, even if their individual contribution is negative. Busch et al. (2020) find welfare gains from the 2015-2016 refugee inflow in Germany, provided low-skilled natives are compensated.

[4] Clemens (2022) shows that another indirect effect arises from the increase in capital that arises in response to immigration.

D'Albis et al. (2019) used a time series approach with a panel of OECD countries and conclude that immigration increases the employment rate and through that brings a positive dividend to the fiscal balance. Furlanetto and Robstad (2019) find similar results in a time series setting, leveraging higher-frequency data on immigration available in Norway. While we do not model labor market responses to changes in immigration policies, our methodology is robust to such a response, as our fiscal imbalance metrics are not sensitive to changes in labor productivity. Our results suggest that while the indirect effects may be significant in the short run, they are small in the long run when compared to the role of population dynamics and how they are influenced by immigration flows.

Our results are also relevant for political economy and demographic economics. First, we uncover substantial heterogeneity across Euro area countries in how immigration alleviates the fiscal burden of aging. As a result, a uniform restriction to immigration at the EU level would have markedly different fiscal impacts across different countries, potentially deepening disagreements on migration policy. See Alesina and Tabellini (2024) for an overview of this topic.[5] Second, we further show that marginal increases in native or immigrant fertility have little impact on fiscal sustainability unless fertility reaches replacement – a highly unlikely prospect.[6] Higher fertility generates a lower dependency ratio in the long run, and therefore a higher share of workers, but also increases education costs in the short run, resulting in a roughly neutral overall impact.

Organization The rest of the paper is organized as follows. Section 2 describes the population projections and some theoretical results of this class of models. Section 3 presents how we estimate the demographic profiles of different budget items and the current net contributions to the government budget of each demographic group. Section 4 describes the results on the role of migration for long-run European public finances. Section 5 shows the cross-country heterogeneity results. Section 6 concludes.

2 Population Projection Model

We consider a classic cohort-component model. This is the standard method used by different statistical offices worldwide, such as Census Bureau or Eurostat, in their official population projections. Unlike some previous studies on the fiscal impact of immigration, that take as given the projections prepared by these sources, in this section we analyze the population model in detail, highlighting some important theoretical results and building projections under different migration scenarios.

[5]Specifically, several studies show that the fiscal effects of immigration are a first-order driver of anti-immigration sentiment in European countries (Dustmann and Preston, 2007; Hanson et al., 2007; Alesina et al., 2018). Alesina et al. (2023) show that immigration changes the support for redistribution.

[6]For a review of the key arguments in the literature for why replacement fertility is "neither natural nor optimal nor likely", see Weil (2023).

2.1 Model Description

The population is split by groups who evolve over time through some individuals dying and a flow of new immigrants entering. The number of individuals alive in period t with age a, gender g and country of birth group c, given by $P^c_{t,a,g}$, evolves according to

$$P^c_{t+1,a+1,g} = (1 - m_{t,a,g,c})P^c_{t,a,g} + \overline{I}^c_{t,a,g}, \tag{1}$$

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 group c. Newborns are given by

$$P^c_{t,0,g} = \sum_{a,g,c} P^c_{t-1,a,g} f^c_{t-1,a,g} \lambda + \bar{I}^c_{t,0,g}, \tag{2}$$

where $f^c_{t,a,g}$ 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.

2.2 Theoretical Results on the Age Structure of Population

For the sake of simplicity in exposition, let us now consider a version of the model above with only three ages (young, adult and old) and no gender differences. There are two subpopulations indexed by $i \in \{N, F\}$, based on the country of birth (native and foreign). Each of the subpopulations' law of motions can be cast as a simple linear differences model in state space form:

$$\mathbf{P}^i_t = A\mathbf{P}^i_{t-1} + B,\ i = \{N, F\} \tag{3}$$

where $\mathbf{P}^i_t = \begin{bmatrix} P^i_{o,t} & P^i_{a,t} & P^i_{y,t} \end{bmatrix}'$, $B = \begin{bmatrix} 0 & \bar{I} & 0 \end{bmatrix}'$, with $\bar{I} = 0$ for $i = N$. The transition matrix A is given by

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

where π_m is the probability of death, π_o is the probability of entering retirement, π_a is the probability of entering adulthood, and f is the fertility rate. Under reasonable parameter restrictions, and in the case of fertility below replacement ($f < \pi_o$), matrix A is invertible so we can solve the model backwards:

$$\mathbf{P}^i_t = A^t\mathbf{P}^i_0 + (I - A^t)(I - A)^{-1}B. \tag{4}$$

The stationary population is given by

$$\lim_{t\to\infty} \boldsymbol{P}_t = (I-A)^{-1}B = M \times \frac{1}{\pi_o - f} \times \begin{bmatrix} \frac{\pi_o}{\pi_m}, & 1, & \frac{f}{\pi_a} \end{bmatrix}'$$

This means that with fertility below replacement and no migration the population becomes extinct. Any positive inflow of migrants avoids population extinction, such that the long-run population only comprises immigrants. This also means that the size of the immigration flow only matters for determining the scale of the stationary population, not its age structure. This population is called "stationary through immigration" (SI) in the demography literature (Espenshade et al., 1982).[7] In a SI population, the group comprising "natives" and their descendants still becomes extinct. The long-run population is composed only of successive generations of immigrants.

Over the transition, i.e. for any finite t, the native and foreign populations will be determined by:

$$\begin{cases} \mathbf{P}_t^N = A^t \mathbf{P}_0^N \\ \mathbf{P}_t^F = A^t \mathbf{P}_0^F + (I - A^t)(I-A)^{-1}B \end{cases} \tag{5}$$

The foreign population is composed of: i) a transient component, the initial population and its descendants, that will vanish as $t \to \infty$ like the native population; ii) a permanent component associated with the successive generations of new immigrants. Let the number of individuals in the transient component be termed $\bar{P}_t^i \equiv \mathbf{1}' A^t \mathbf{P}_0^i$. The share of immigrants in the total population is then given by:

$$\frac{P_F}{P_N + P_F} = \frac{\bar{P}_t^F + \mathbf{1}'(I-A^t)(I-A)^{-1}B}{\bar{P}_t^N + \bar{P}_t^F + \mathbf{1}'(I-A^t)(I-A)^{-1}B}$$

After some algebra, it can be seen that the component associated with new immigrants has the form:

$$\mathbf{1}'(I-A^t)(I-A)^{-1}B = \frac{M}{\pi_o - f}\chi_t,$$

where $\chi_t \equiv \sum_{k=1}^{t} X_k\left(f, \pi_a, \pi_o, \pi_m\right)$, with X_k being some polynomials of order k in the transition parameters, crucially not including M. It also turns out that χ_t is always positive, given parameters within $(0,1)$. The derivative of the immigrants' share with respect to the flow M is:

$$\frac{\partial}{\partial M}\left(\frac{P_F}{P_F + P_N}\right) = \frac{\frac{\chi_t}{\pi_o - f}\left(\bar{P}_t^N + \bar{P}_t^F\right)}{\left(\bar{P}_t^N + \bar{P}_t^F + \frac{M\chi_t}{\pi_o - f}\right)^2}.$$

This derivative is positive given that $\chi_t > 0$ and $\pi_o > f$, so a higher M increases the share of immigrants at any t. As M increases, the denominator grows, reducing the impact of further increases of the flow on the share of immigrants for a given t (it is straightforward to see that the second derivative is always negative).

[7] This result does not depend on immigrant fertility rates above replacement. It requires, though, that some n-th generation of immigrants' descendants has fertility below replacement. If all immigrants and their descendants have fertility above replacement, there is no stationary population as the long-run population growth rate is positive.

Since the dependency ratio of the total population will be a "weighted average" of the dependency ratio of the two groups, each converging smoothly to their respective steady-states, the above implies the decreasing effect of M on the population dependency ratio.

Note that these dynamics are present in any population model with this structure. Therefore, the results of most preceding papers on the fiscal effects of immigration, which use such models, also depend on this effect. These dynamics had not been explained before in the literature, to the best of our knowledge, but should be taken into account in interpreting such results. In Appendix A, we complement this analysis with numerical simulations to illustrate these dynamics.

2.3 Data Sources and Assumptions for Projections

Our main exercises rely on a full-blown version of this population projection model described in Equations (1) and (2). For each country, we project population stocks along three dimensions: age, gender, and country of birth.[8] 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", people born in the EU and their descendants, and "migrants", people born outside the EU and their descendants (which in the data come mostly from developing countries). Finally, we consider three education categories: primary, secondary and tertiary education.[9]

In implementing this population projection model, we take 2019 as the starting year. This avoids the effects of the pandemic, 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.[10]

Fertility rates differ by age and country of birth group and vary over time. We take values for each EA country from the EUROPOP2019 central projection forecasts (Eurostat, 2020). The total fertility rate of natives starts off slightly over 1.4 and slowly increases over time, though still remaining well below the replacement rate of 2.1 children per woman, reaching around 1.6 by 2100 (see Appendix C.3). First-generation migrants born outside the EU have fertility rates above replacement, which we take from Eurostat data for 2019, where their total fertility rate is 2.4. We assume this converges to 2.1 by 2100 (our results are robust to this assumption, as shown in Appendix E.3). We assume that their descendants exhibit the same fertility as natives (this assumption does not also have meaningful effects on any of our results; see Appendix E.2).

Mortality rates are also taken from Eurostat data and their EUROPOP2019 assumptions. Life expectancy at birth was around 81 years old on average in 2019, and is assumed to rise (and converge

[8]The countries considered are Austria (AT), Belgium (BE), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxembourg (LU), the Netherlands (NL), Portugal (PT), Slovakia (SK), Slovenia (SI), and Spain (ES). We exclude Cyprus and Malta as they have a large non-resident population in the working force that does not appear in the migration numbers but are relevant for public finances purposes.

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

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

between countries) to around 88 years old by 2100. Mortality rates differ only by age and gender, and therefore are common across country of birth groups and education levels.[11]

In our empirical application, after projecting the population by age, gender, and country of birth, each cohort is further split by education level. The population is split by education and country of birth groups using available data from Eurostat. This is crucial for an accurate measurement of the immigrants' contribution to the budget. As to the future path of education levels, we build it based on a conservative invariance assumption. Specifically, we assume that each young and unborn cohort attains the same education levels as the cohort aged 25 in 2019, and that after the age of 25 the education composition of each cohort remains constant. We take the evolution of education up to 25 years old, and of cohorts older than 25 in 2019, from the aforementioned Eurostat dataset. This invariance assumption still implies that the overall education level of the projected population will increase over time as older cohorts, who generally have lower education, are replaced by younger, more educated ones.

Finally, in each scenario the net migration flow does not change over time. This assumption is consistent with official demographic projections, such as those routinely performed by Eurostat or the Census Bureau. These projections account for ongoing shocks that affect net migration inflows, but for the medium- and long-run they assume a constant net migration flow. Forecasting future migration shocks is challenging as they depend, for example, on wars or natural disasters that are generally unpredictable. Further, the age, gender and education distribution of this flow is also assumed to be constant. So, in the different scenarios for migration that we run, we vary the size of the net migration inflow, but keep the age and education distribution of new immigrants fixed. Appendix C.3 describes more details about these population projections.

2.4 Projection Results

In 2019, the starting point of our projection, about 342 million people lived in the Euro Area. Table 1 compares the population composition by country of birth in terms of age and education in 2019. Panel (a) of the Table shows the age composition. Non-EU-born population is heavily concentrated in working ages with more than two-thirds with ages between 25 and 65 years old. Contrarily, the EU-born population is almost split in half between dependent groups (young and old) and the working-age group.

Panel (b) of Table 1 shows the education composition of the population above 25 years old by country of birth in 2019. For both country of births, the largest group attained secondary education, which corresponds to completed high school. The native population is, however, more educated with more than 30% of the population above 25 years old having tertiary education (a university degree), comparing with only 25% among non-EU-born population.

[11] 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.

Table 1: Composition of Population by Country of Birth in 2019

Age in 2019	EU-born	non-EU-born
0–25 years old	29.3%	17.5%
26–65 years old	54.9%	71.0%
>65 years old	21.4%	11.5%

(a) Age (full population)

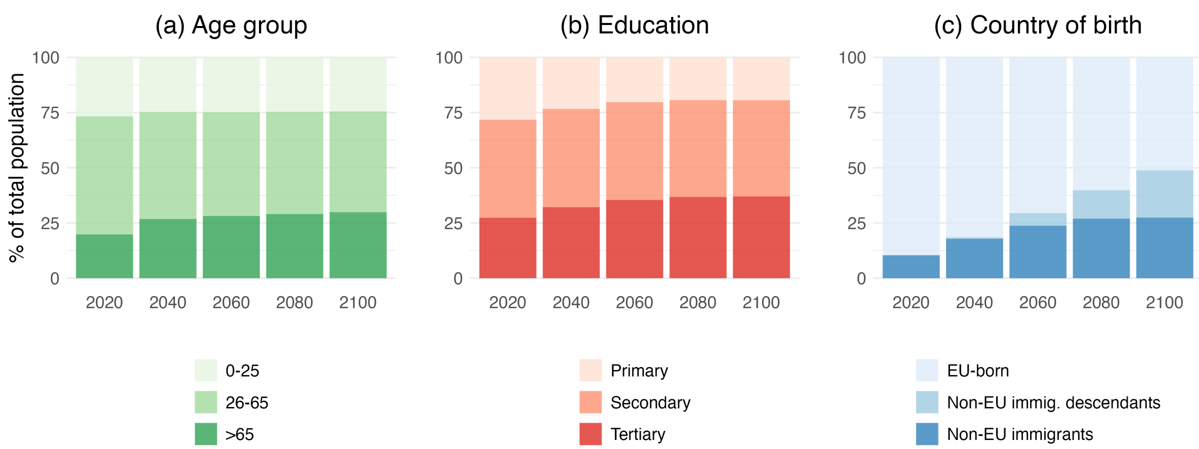
Level of education attained	EU-born	non-EU-born
Primary	30.8%	41.0%
Secondary	45.1%	33.9%
Tertiary	30.9%	25.1%

(b) Education Level (population above 25 y.o.)

Note: The tables above describe the composition of the resident population in the EA in 2019 by age and education, looking separately at groups based on country of birth. Panel (a) shows the age composition of each group, while panel (b) shows the composition in terms of attained education, considering only residents above 25 years old. Primary education corresponds to below high school attainment (ISCED 0–2), secondary education corresponds to completed high school education (ISCED 3–4), and tertiary education corresponds to a university degree (ISCED 5–8).

Using the population projection model described by Equations (1) and (2), we forecast, for each country of the EA, the population stock until 2100. After that year, we assume a constant population. By 2100, we project that 330 million people will live in the EA. Figure 2 plots, for selected years of the projection, the implied EA age, gender, education level, and country of birth distribution.

Figure 2: Demographic Distributions Implied by the Population Projections



Note: The figure shows the percentage of people with given demographic characteristics for selected years of the projection. Panel (a) displays the age distribution by age group (young, working-age, and old-age). Panel (b) presents the education level distribution as a percentage of the adult population (primary corresponds to below high school attainment, secondary corresponds to completed high school education, tertiary corresponds to a university degree). Panel (c) depicts the distribution of country of birth as a percentage of the adult population. The group of non-EU immigrant descendants includes only those born from 2019 onward, with preexisting descendants included in the EU-born group. Finally, the gender distribution is not plotted but it remains constant around 50% throughout the projection.

In our baseline projection, the population ages significantly. 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, in line with Eurostat projections. 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. At the same time, as life expectancy continues to rise, the share of the population with more than 65 years old increases by more than 10 percentage points. over the projection time span. The gender distribution, not plotted, is projected to remain constant, with the female population making up slightly half of the total population, as female life expectancy is slightly larger than male life expectancy.

Our demographic forecasts also imply the education levels distribution of the adult population will change, as panel (b) illustrates. As described above, we assum that the education distribution verifyed at age 25 in 2019 is the distribution that new cohorts attained once they reach the same age. This implies that the percentage of population attaining secondary and, especially, tertiary education will increase over time. In fact, the share of adult population with the highest education 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 15 percentage points, and the children of this part of the population are projected to represent 25 percent of the adult population in 2100. Non-EU-born population are characterized by having a higher fertility rate than the native population and our projections encompass a yearly constant flow of immigrants. At the same time, native fertility is below replacement which means that the native group is shrinking. Consequently, the population projections imply that the share of non-EU born and their descendants increase over time, representing around 50% of the population by 2100.[12]

3 A Framework to Measure the Fiscal Burden of Aging

In this section, we describe how we map the different budget aggregates into the demographic groups considered, by building the demographic profile of the government budget. We then combine this profile 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 The Rebalancing Tax Increase

We divide the population in demographic groups by age, gender, education level and country of birth, the same groups that we consider in the population projection model. For each of these

[12] Our data does not allow to break down the resident population in 2019 by the country of birth of parents. Estimates by Eurostat on Labour Force Survey data place the share of the working-age population that is a descendant of at least one foreign-born person (including both intra-EU and extra-EU) at 7.3% for the whole EU in 2023.

groups, we want to estimate its net contribution to the government budget. For that we need to compute how much they pay of each tax item (e.g. personal income tax) and how much they receive and benefit from each expenditure item (e.g. healthcare). Let $\tau^i_{t,x}$ be the average per capita government revenue of category i that is attributed to an individual of demographic group x in the year t, and $g^i_{t,x}$ is the average per capita government expenditure of category i attributed to a person of demographic group x in year t.

The sets $\{\tau^i_{t,x}\}$ and $\{g^i_{t,x}\}$allow us to build the demographic profile of the government budget in year 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:[13]

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

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. In Appendix B we describe this model that is similar to the one developed by Storesletten (2003).

We next derive a metric for the fiscal burden of aging. 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, including policy changes. 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:[14]

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

Total government revenues are the sum of all revenue items, and each revenue item is the sum across demographic groups of the product between the population stock and the demographic profile of that group, i.e. $T_t = \sum_i \sum_x \tau^i_{t,x} P_{t,x}$, and similarly for government expenditures. We introduce a wedge $(1+\theta_\tau)$ in the above equation, which corresponds to a proportional adjustment factor to revenues necessary to the IGBC to hold. 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 $B_{\bar{t}-1}$, this adjustment factor is implicitly given by:

[13] 2019 is a good year to estimate the demographic profiles as it does not suffer from any contamination from the 2020-2021 health crisis and subsequent 2022-2023 cost-of-living crisis.

[14] To be precise, the IGBC should also include the term $\lim_{s\to\infty} \prod_{j=1}^{s} \frac{B_{\bar{t}+s}}{(1+i_{\bar{t}+j})}$. Public finance sustainability implies that the government is solvable and hence Ponzi schemes cannot happen.

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

with $D_t \equiv \frac{(1+\gamma_t)(1+\pi_t)}{1+i_t}$, which represents the growth/discount factor.[15] 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. Furthermore, the same exercise could be performed by instead introducing an adjustment factor on government expenditure, which 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.[16]

Cash-flow accounting methods such as the GA framework we use here can be subject to some bias. We correct for two of them.[17] First, 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.

Second, our accounting method assumes prices do not adjust, which implies that immigration, that leads to an increase in employment, must be met by additional capital. This generates more capital income, and consequently higher tax revenue. In our case, this bias can be particularly relevant since immigration is mostly concentrated in working ages. Clemens (2022) proposes a simple adjustment that accounts for this omission, which we adopt here as well.

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 grow uniformly for all demographic groups, 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 closely related with the evolution of the dependency ratio.

For comparison purposes with other studies that have been done on the impact of demographics on public finance, we also report the traditional GA metric following Auerbach et al. (1991) (θ_τ^{AGK}). This metric represents the change in revenues solely attributable to future generations necessary to ensure intertemporal fiscal balance, while taxes for current generations remain unchanged.[18] We

[15] For simplicity, we assume that the productivity growth rate, the inflation rate and the interest rate are constant and equal to the long-run average.

[16] Blanchard (1990) argues why an indicator such as θ_τ is the most appropriate measure of long-run fiscal sustainability.

[17] We briefly describe the adjustments here. In Appendix C.1, we explain them in detail.

[18] The generational distribution of the fiscal burden of aging it implies is likely very unrealistic. Furthermore, the

report the value of this metric in Section 4, alongside the rebalancing tax increase.

3.2 Data Sources and Methodology

In this subsection, we explain the data and methodology used to estimate the demographic profiles, $\{\tau^i_{t,x}\}$ and $\{g^i_{t,x}\}$. As for the population projections, we obtain data for all countries that were part of the EA in 2019, except for Malta and Cyprus.

Data. To estimate the demographic profiles we use two types of data. First, we use 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. Second, as we want our exercise to be consistent with the national accounts, we use 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. This allows us to estimate the demographic profile of personal income tax, social security contributions, property tax, old-age pension, survival pension, disability pension, unemployment 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.[19]

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.[20]

Macro-aggregates on taxes and benefits come from the Eurostat. We also use data on productivity growth rate, the inflation rate and the interest rate to compute the discount factor, as well as public debt. Appendix D contains the list of variables used from the different data sources.

metric is very sensitive to the value of D. See Rowthorn (2008) for a discussion. In Appendix C.2, we describe in more detail this metric.

[19]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.

[20]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. (2022).

Methodology. To estimate the demographic profiles we proceed in two steps. First, we estimate a quasi-saturated regression model of country and demographic groups for each tax/benefit item:

$$
\begin{aligned}
Y_j \; &= \alpha + \beta^{\text{country}} \cdot \text{country}_j \\
&\quad + \gamma^{\text{age}\times\text{country}} \cdot (\text{age}_j \times \text{country}_j) + \phi^{\text{gender}\times\text{country}} \cdot (\text{gender}_j \times \text{country}_j) \\
&\quad + \delta^{\text{educ}\times\text{country}} \cdot (\text{educ}_j \times \text{country}_j) + \kappa^{\text{CoB}\times\text{country}} \cdot (CoB_j \times \text{country}_j) \\
&\quad + \eta^{\text{gender}\times\text{educ}\times\text{country}} \cdot (\text{gender}_j \times \text{educ}_j \times \text{country}_j) \\
&\quad + \psi^{\text{age}\times\text{gender}\times\text{country}} \cdot (\text{age}_j \times \text{gender}_j \times \text{country}_j) \\
&\quad + \theta^{\text{educ}\times\text{CoB}\times\text{country}} \cdot (\text{educ}_j \times \text{CoB}_j \times \text{country}_j) \\
&\quad + \lambda^{\text{CoB}\times\text{age}} \cdot (CoB_j \times \text{age}_j) + \mu^{\text{CoB}\times\text{gender}} \cdot (CoB_j \times \text{gender}_j) + \varepsilon_j
\end{aligned}
\tag{9}
$$

where Y_j denotes the value paid or received by individual j of a given budget item, $country_j$ is the vector of the EA country dummies, age_j indicates the individual's age bracket (groups of 5 ages), $educ_j$ denotes the education level group (primary, secondary and tertiary), $gender_j$ is a gender indicator (male and female), and CoB_j is the individual's country of birth group (EU and non-EU). With this specification, we estimate country-specific age, gender, education and country of birth profiles. The interaction terms allow for country-specific gender-education differences, gender-age differences, and education-country of births differences profiles. Furthermore, our specification also allows for country-of-birth-specific age and gender profiles.

In a second step, using the estimated coefficients, we predict for each country, age bracket, gender, skill level and country of birth, how much, on average, an individual contributes to each revenue item and receives from each benefit item. For the items estimated using the HFCS data, we do not distinguish by gender, as the unit of observation is the household.

In total, we estimate the demographic profile of 12 different budget items, that cover about two-thirds of the budget. The remainder of the budget cannot be mapped to a demographic group, due to data limitations or conceptual reasons. Benefits from government activities such as defense, justice, or regulation cannot easily be distinguished between individuals. 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.[21] Appendix C.4 has additional estimation details of these profiles and Appendix F.4 reports the profiles for the budget items.

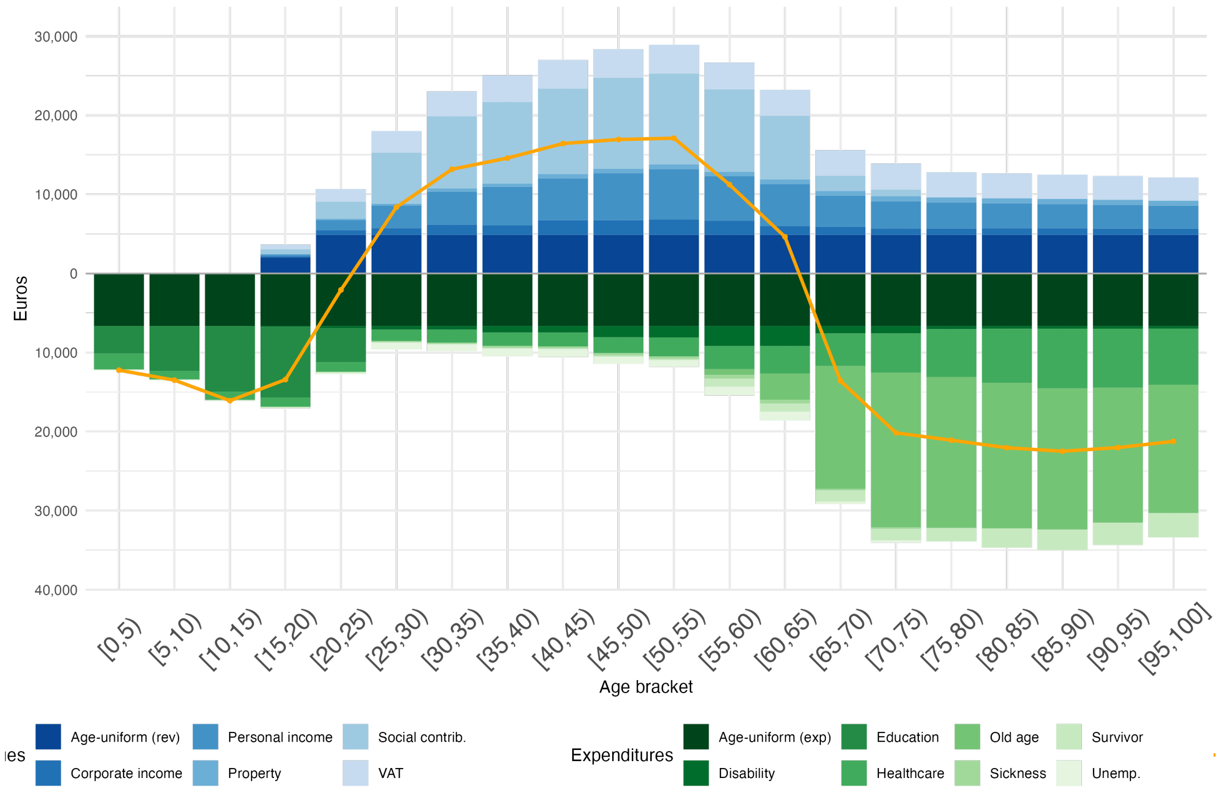
3.3 Demographic Profile of the Government Budget

Figure 3 plots the EA mean age profile of revenues and expenditures per capita, estimated using the microdata sources described above. The top blue bars show, for each age group, the aver-

[21] 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.

age payment in 2019 that an individual does to the government breakdown by revenue category. Similarly, the bottom green bars show, for each age, the average amount received from the government by expenditure category, in the same year. Finally, the yellow line plots the difference between the two which corresponds to the per capita net contribution that each age group does to the government budget.[22]

Figure 3: Mean Age Profile of Revenues and Expenditures Per Capita



Note: The figure shows estimates of mean per capita amounts for the different revenue and expenditure components of the government budget, for the euro area average (weighted by GDP). The orange solid line shows the net contribution by age, which the sum of revenues minus the sum of expenditures. In Appendix F.4 we show the same plot but for each country.

The figure shows the life-cycle pattern of the net contribution with three distinct segments of the population. The first are the young age groups (0–24 years old) that are net receivers from the budget, benefiting mostly from education and paying very little in taxes. The second group are the individuals in the working-age (25–64 years old). These groups are net contributors to the budget as they pay more taxes (personal income tax, VAT and social contributions are the largest items) than they directly benefit. The third segment of the population correspond to the old age groups (65+ years old) that are net receivers from the budget. Despite paying taxes, what they receive from pensions and healthcare services is larger than what they end up paying.

[22]In Appendix F.4, we show for each country and each budget item the demographic profile estimated. We also show the mean age profile for each country separately.

The profile presented above has some differences across education groups and country of birth. Individuals with lower education (primary education attainment) have smaller income which implies they pay less taxes during the working ages, despite receiving similar benefits. This implies they are net receivers from the government budget. On the other hand, more educated individuals (secondary and tertiary education attainment), as they receive a higher income, they tend to pay more taxes making them net contributors to the budget.[23]

In Table 2 we show the net contribution by country of birth (EU-born and non-EU-born) and age group (0–25, 26–65 and >65 years old, the three relevant groups). Column (1) shows the net contribution per capita, which is the sum of the values on the yellow line in Figure 3 over age brackets in each group. As described above, young and old groups have a net negative contribution, whereas working-age groups are net contributors to the budget. There are some differences when we compare the per capita net contribution across country of birth groups, which are mostly driven by the education composition of these groups – non-EU-born have smaller education attainments than EU-born which means they have smaller per capita net contributions.

Table 2: 2019 Primary Budget Decomposition

Country of Birth	Age Group	(1) Net Contrib. (€, per capita)	(2) Pop. (Million)	(3) Contrib. to the Balance (1×2) (Billion €)	(% EA pot. GDP)
EU-born	0–25	-10,635	85.9	-858.4	-7.37
	26–65	13,125	161.0	1,927.3	16.55
	>65	-19,546	63.0	-1,141.1	-9.80
	total	–	311.0	-72.3	-0.62
Non-EU-born	0–25	-8,279	5.3	-40.1	-0.34
	26–65	8,158	21.5	165.0	1.42
	>65	-17,219	3.5	-58.9	-0.51
	total	–	30.3	66.0	0.57
Total		–	342.0	-6.3	-0.05

Note: The table shows, by country of birth and age group, the per capita net contribution in column (1), the population stock of that group in column (2) and the total contribution to the balance in billion Euros and in percentage of the potential GDP in column (3), for the EA.

Column (2) of the same table contains the population of each group and column (3) corresponds to total contribution to the budget which is the product of column (1) and column (2). The same life-cycle pattern of the per capita net contribution emerge here, for both country of birth groups. However, and more interesting, the total net contribution of the EU-born population is negative, whereas the total net contribution of the non-EU-born group is positive which leads to an essentially balanced budget (a small deficit of 6.3 billion euros which corresponds to 0.05% of the EA potential GDP). In other words, without the contributions of the non-EU-born population group, the EA budget would be in a unbalanced position.

[23] In Appendix F.5, we show these mean age profiles by education group and country of birth group.

These results relate with the literature that computes the net contribution of immigrants in a given year. Mackie and Blau (2017) look into the US and show a similar life-cycle pattern of net contribution. They also show that immigrants, in particular second-generation immigrants, once they are independent adults their net fiscal impact is quite positive. Fiorio et al. (2023) show for the EU that between 2014 and 2018, the per capita net fiscal contribution of migrants is substantially higher than natives as they have, on average, a higher taxable income due to their age composition. Dustmann and Frattini (2014) look into the UK between 1995 and 2011 and show that immigrants from the EU have made a positive fiscal contribution, while non-EU immigrants and natives have made a negative contribution.

In the next section, we will introduce population dynamics to study the fiscal burden of aging and the role that immigration could have for attenuating it. We compute the counterfactual government budget balance implied by the population projections. Essentially, we keep the demographic profiles of the budget (that imply the values in column (1) of Table 2) only letting them grow at a constant rate and change the population according to the projection model of Section 2 to compute the counterfactual total net contributions (what we have in column (2) of Table 2) over time.

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

In this section, we study the role of immigration for public finance sustainability. We start by extending the analysis in the previous section and compute the lifetime expected net contribution of different demographic groups. Second, we look into the balance budget evolution implied by those contributions. Then, we present the main results on the impact of changing the net migration flow on public finances. We conclude this section comparing the impact of higher fertility with higher immigration.

Immigration flows are mostly concentrated between the ages of 20 and 40 years old (Figure 1). At these ages, they do not benefit from the education services. Instead, they come at an age where they mostly contribute to the government budget by paying taxes and social contributions. Due to their age composition, their average net contribution is better than the average net contribution of the natives, even though the per capita contributions are smaller, as Table 2 shows.

In Table 3, we show the expected lifetime net contributions in 2019 at birth and at age 30 by country of birth. For a person aged a_e in 2019, this is given by:

$$\sum_{a=a_e}^{100} \sum_{i} D^{a-a_e} \left[\tau^i_{\bar{t},a,x'} - g^i_{\bar{t},a,x'} \right] \left(1 - \pi^X_{a,x'}\right) \left(1 - m_{a,x'}\right),$$

where D, τ^i and g^i are defined as before, π^X is the probability of out-migration (as implied by the population data), m the mortality rate, all of which are defined by age a and by other demographic characteristics than age, which are constant and denoted by x' . This accounts for the projected taxes and benefits that will be paid over an individual's life cycle within our projection framework.

The numbers in the table are the yearly annuity corresponding to the present value of this lifetime net contribution.

Table 3: Expected lifetime per capita net contributions in 2019

Country of Birth	Net Contribution		Tax payments	
	At birth	At age 30	At birth	At age 30
EU-born	-5,051	2,160	37,117	37,123
Non-EU-born	-9,757	-2,697	29,837	29,369

Note: Annuity values, in Euros per year. The table shows, for a person at birth and at the age of 30 in 2019, by country of birth group, the average projected lifetime net contribution and tax payments.

The expected lifetime net contribution at birth is very different across country of births. EU-born, on average, have a lifetime net contribution of €-5,051 per year, whereas non-EU-born have an average lifetime net contribution of €-9,757/year. This difference is similar across other ages. However, the population age-distribution differs by country of birth with the non-EU-born population being more concentrated at working ages than the EU-born population. This means that when they enter in Europe they represent a smaller burden for public finances than EU-born population, being the major difference the education costs that European governments have before the age of 25.

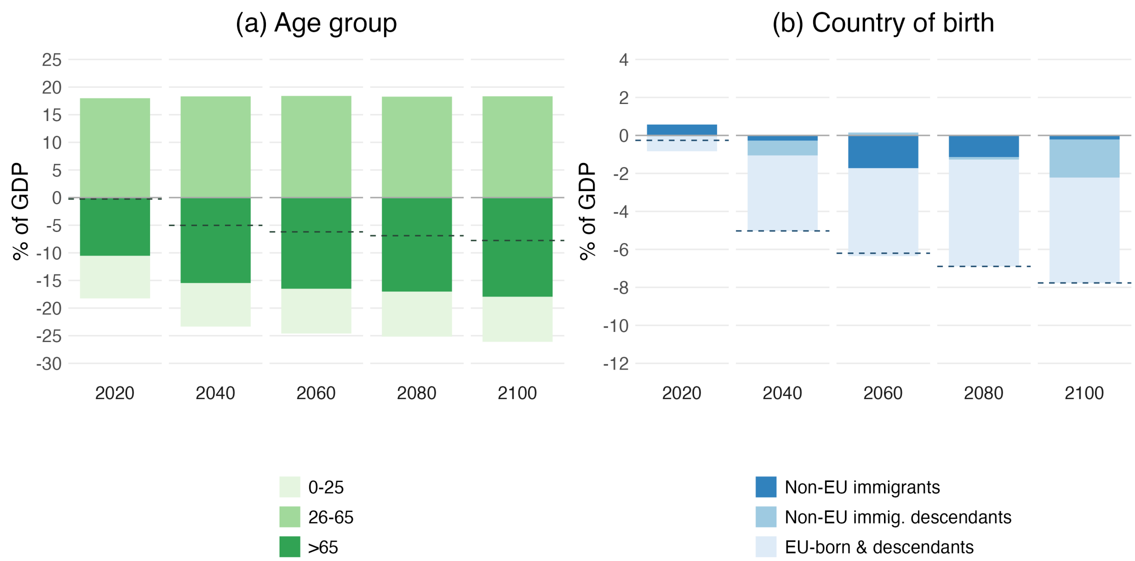
4.1 The Fiscal Burden of Aging in Europe

Building on the framework described in Section 3, we quantify the fiscal burden of aging in Europe. We begin by computing the lifetime net contributions, which we then aggregate to calculate the primary balance and the rebalancing tax increase necessary to achieve public finance sustainability.

As shown in Section 2, the population of the EA will age over the coming decades, with the dependency ratio increasing substantially. This trend will strain public finances, as the share of net contributors in the population declines. To measure this fiscal burden of aging, we build the counterfactual government budget implied by our population projections, keeping fixed the demographic profiles of revenue and spending items, as estimated in Section 3.

Figure 4, presents the resulting primary balances for selected years of the projection. The initial deficit, 0.2 percent of 2019 potential GDP, widens over time. By 2040, the primary deficit would be 4.7 percent, and by 2100, it would be almost 9 percent of potential GDP. Although with varying intensity and speed, we can observe the same trend across the EA countries. See Appendix F.3 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 figure shows the net contribution to the EA primary balance for selected years of the projection of each age group – panel (a) – and of each country of birth group – panel (b). The dashed lines in the figure represent the primary balance. All values are shown as a percentage of the potential GDP.

Panel (a) of Figure 4 also shows, for selected years, the decomposition of the primary balance by age group. As the population share of older age groups increases, so does their negative effect on the budget balance, increasing from around 10 percent of the potential GDP in 2019 to almost 20 percent of the potential GDP in 2100. The young generations' negative contribution is relatively stable throughout the projection period. 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 between EU-born "natives" and immigrants from outside the EU.[24] The negative net contribution from "natives" is projected to widen as this group quickly ages. In the last decades of the century, even though "native" groups compose only about half of the population, they are responsible for three quarters of the projected deficit.

While the immigrant group initially has a positive net contribution, it also becomes a net recipient after 2040. This is due to life-cycle effects that immigrants also experience: when these individuals immigrate, they are mostly at working age and hence contributing positively to the government budget. Eventually, they will also retire, becoming net beneficiaries. As a whole, the immigrant group will also be 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. The descendants of non-EU immigrants have a negative contribution throughout the projection period, except for some years around 2060 where they have a positive although negligible net contribution.

[24]For completeness, in Appendix F.5 we also show the decomposition of the primary balance by gender and education level.

We summarize the fiscal burden of aging by measuring the rebalancing tax increase, θ_τ, defined previously in Equation (8). This indicator tells how much would governments need to increase taxes to rebalance public finances, under the counterfactual budget. For presentation purposes, we compute the EA average weighted by the 2019 potential GDP of the metric. The average rebalancing tax increase is 14 percent, for everyone and permanently. This means an additional 5.9% of GDP in revenues each year, compared with the current 42% of GDP collected in taxes and social contributions. If the tax increase affected only generations born after 2019, it would need to be 28.3 percent.

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.

4.2 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.

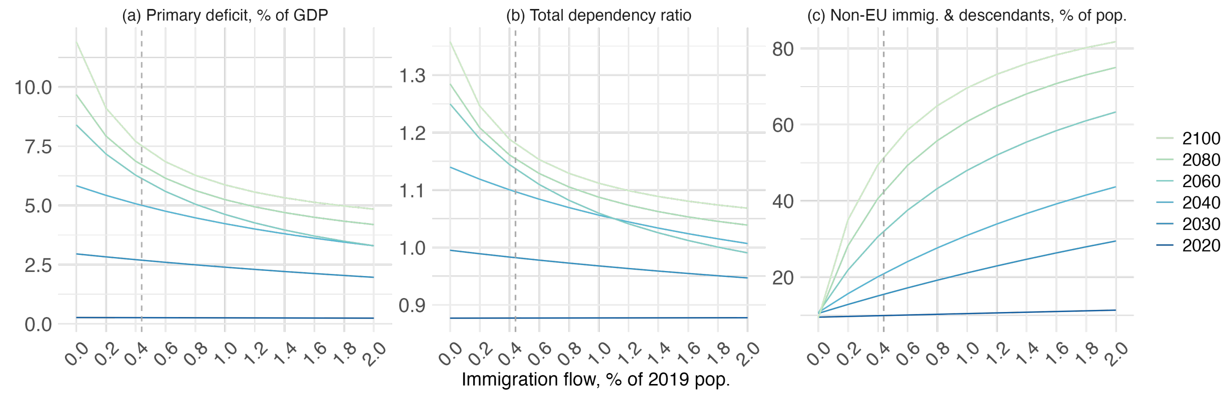
4.2.1 The Nonlinear Effects of Immigration on the Primary Deficit

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 scenarios where we change the intensity of net migration flows. The age/gender/education distribution of incoming net migration is kept equal to that observed in 2019, with only the scale of net migration flows changing across scenarios.[25]

Figure 5 shows the results of this exercise, plotting for selected points in the projection horizon different variables along the migration scenarios. Panel (a) shows the primary deficit in percentage of the potential GDP, panel (b) shows the total age dependency ratio and panel (c) the share of non-EU immigrants and their descendants in the total population.

[25] 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 age-dependency ratio (computed as the sum of the young and old populations divided by the working-age population) for these same net migration scenarios. Panel (c) shows the share of non-EU born and descendants in the population stock for the same net migration scenarios. The dashed line in all three panels indicates the size of migration flows in the baseline scenario.

Panel (a) shows that, regardless of the level of migration, the current small primary deficit will increase over time. 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 always 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 along the horizontal axis of the figures. 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 as shown in Table 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, the effect of intensifying immigration flows on the deficits is positive, but diminishing, while constraining migration has increasing effects: the fiscal costs of "building walls" increase with the size of the restriction. By 2100, a smaller immigration flow by 0.4 p.p. (i.e., a shut down of the net migration flow) would lead to a deficit larger by about 4.1 p.p., while a larger immigration flow by 0.4 p.p. (i.e., doubling the net migration flow) would only reduce the 2100 deficit by 1.5 p.p.

This non-linearity is rooted in population dynamics, as explained in Section 2. To see this, turn to panel (c) of Figure 5, which shows the share of non-EU immigrants and their descendants in the total population. Stronger immigration flows lead to a larger share of immigrants in the population, with the marginal effect decreasing at any given year.

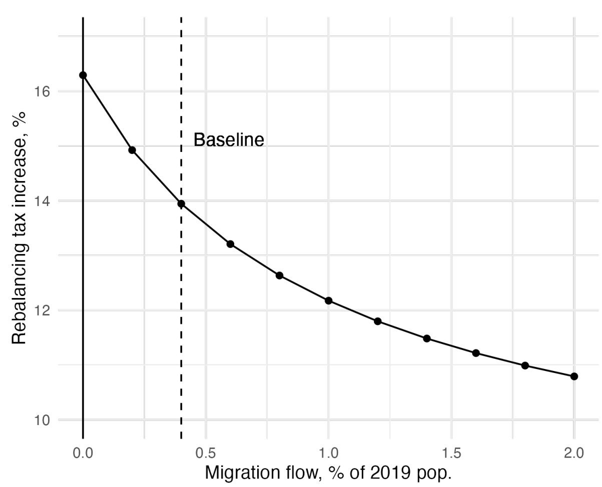
4.2.2 Implications for the Fiscal Burden of Aging

The interpretation of these dynamics is clear. As fertility is below replacement, the population of Europe is undergoing a transition towards a "stationary through immigration" population, i.e. one which is only sustained by a regular inflow of migrants. Increasing the immigrant flow accelerates that transition, but there is a limit to that acceleration. This is why immigration alone cannot solve the fiscal burden of aging and, conversely, why the "costs of building walls" are increasing. 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, due to the convergence result discussed in Section 2.

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). 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 presented above, in the baseline scenario where the net migration flow is equal to 0.4% of the 2019 population, the rebalancing tax increase is 14 percent. The necessary tax adjustment 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.

Figure 6: Frontier between the Level of Net Migration and the Rebalancing Tax Increase, θ_τ



Note: The figure shows the rebalancing tax increase, θ_τ, for the different net migration scenarios. This metric corresponds to the weighted average of the country-specific rebalancing tax increase metrics across the EA countries, using the 2019 potential GDP as weights. The dashed line indicates the size of migration flows in the baseline scenario.

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 1.4 percentage points. These gains are smaller in size, compared to the costs of shutting down migration. In this case, the rebalancing tax increase would be 2.3 percentage points larger. In this sense, increasing migration has diminishing returns for public finances. Table 4 shows the rebalancing tax increase and the traditional GA metric (Auerbach et al., 1991) for three net migration scenarios.

Table 4: Imbalance Metrics in Different Migration Scenarios

Size of net migration flow	θ_τ	θ_τ^{AGK}
0.4% of 2019 pop. (baseline)	14.0%	28.3%
0.8% of 2019 pop. (doubling)	12.6%	22.5%
0.0% of 2019 pop. (shut-down)	16.3%	45.1%

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 the same weights and they are described in Appendix C.2. The table reports these metrics for the baseline net migration flow (0.4% of the 2019 population) and two alternative net migration scenarios: doubling the inflow (0.8%) and shut-down the inflow (0%) .

Shutting down the net migration flows means an additional permanent tax increase of 1% of the EA potential GDP, every year, on top of the 5.9% of the baseline, to restore fiscal sustainability. Table 5 shows, from an individual perspective, this tax increase. It corresponds to an annualized value of €6,048 per year for the average native 30-year-old worker, compared to €5,203 per year with baseline immigration. For a non-EU-born taxpayer, the difference is slightly smaller: €4,785 with a zero net migration flow which compares with €4,116 with the baseline net migration flow.

Table 5: Expected lifetime contributions and tax increase for taxpayers aged 30 in 2019

Country of Birth	Net Contribution	Tax payments	Tax increase by θ_τ		
			Migration flows 2019-...		
			$\approx 0.4\%$	0.0%	Diff.
EU-born	2,160	37,123	5,203	6,048	-845
Non-EU-born	-2,697	29,369	4,116	4,785	-669

Note: Annuity values, in Euros per year. The table shows, for taxpayers aged 30 in 2019, by country of birth group, the average projected lifetime net contribution and tax payments, and, for the baseline and no-migration scenario, the additional payments corresponding to the rebalancing tax increase, along with their difference.

A potential caveat in our results concerns the general equilibrium effects of immigration. Immigration expands the labor force, which tends to lower wages and raise interest rates due to an increased labor-to-capital ratio. These dynamics can increase the cost of servicing public debt and reduce labor tax revenues. However, Colas and Sachs (2024) argue that such effects may be mitigated in the presence of complementarity between low- and high-skill workers. Since most immigrants are low-skilled, their presence can boost the productivity of high-skilled natives and due to the progressivity of the tax system the wages and tax contributions, partially offsetting the negative general equilibrium impacts. Indeed, the authors show that these indirect fiscal gains may outweigh the direct fiscal costs.

Similarly, Busch et al. (2020) find that the general equilibrium effects of immigration can be modest in a similar setting. Analyzing the large influx of refugee migration to Germany, they report small net welfare gains that grow over time: 0.5% welfare increase in 2020 and 1% welfare increase by 2060. These gains persist despite the downward pressure on wages, suggesting that the main channels operate through demographic change: the influx of migrants increases the working age population, which in turn contributes to a smaller dependency ratio and fiscal cost-to-benefit ratio, which alleviates the tax burden on native workers.

Another potential source of general equilibrium effects is the positive response of immigration flows to better fiscal conditions in the destination country that could downward bias the effects of immigration. While this could be possible in theory, our analysis treats migration flows as exogenous. Moreover, long-term fiscal conditions in host countries are unlikely to be a primary determinant of migration decisions, especially when compared to more immediate factors such as current levels of taxes or socio-economic conditions in the origin country, linguistic ties, and geographic proximity (Mayda, 2010; Grogger and Hanson, 2011).

That said, looking again at Figure 6, we see that immigration cannot per se eliminate the fiscal burden of aging. Even after increasing net migration flows to 2%, an unrealistically large number, fiscal sustainability would still require an 10.8 percent rebalancing tax increase.

4.3 Is Fertility an Alternative to Migration?

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 6. 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);[26] 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, only decreasing by 0.65 percentage points. In contrast, when we increase the

[26] 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.

net migration flow to 2019 levels (Scenario C), the rebalancing tax increase falls by 2.28 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.

Table 6: Imbalance Metrics in High Native Fertility Scenario

Scenario	Native fertility	Net migration flow	θ_τ	θ_τ^{AGK}
A	Baseline (1.6 in 2020+)	0.0% of 2019 pop.	16.3%	45.1%
B	High (2.1 in 2020+)	0.0% of 2019 pop.	15.6%	36.2%
C	Baseline (1.6 in 2020+)	0.4% of 2019 pop. (baseline)	14.0%	28.3%

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. The table reports these metrics for a scenario with high fertility (B) and a scenario with positive net migration flow (C) that compare with scenario A where fertility and migration are low.

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 later.[27] 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.

4.4 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.

Immigrants' Offspring Fertility. In the baseline exercise, the second and later generation of immigrants follow the same demographic behaviors as the native population group. An alternative modeling choice is to set the immigrant offspring fertility equal to the first generation of immigrants. In Appendix E.2, we show the results of an alternative exercise where second-generation

[27]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. The full projected time path for the primary deficit (analogous to Figure 5) is available in Appendix F.1.

immigrants have the same fertility as their immigrant parents. Fiscal balances are slightly worse with this higher fertility, for any level of immigration flows, but differences are subdued. We also observe that the nonlinear relationship between the rebalancing tax increase and the net migration inflow level remains.

Fertility Rate of Immigrants. All the results shown so far rely on the same assumption for the fertility rate of first-generation immigrants, taken from the data to be 2.35 (on average across countries and ages) in 2019 and assumed to slowly decline, converging towards 2.1 children per woman by 2100. This assumption could have an impact on the measured fiscal benefits of migration. In Appendix E.3, we test for that by computing the rebalancing tax increase with different assumptions for the immigrant fertility rate,[28] as well as the frontier between θ_τ and the level of migration. The convexity is observed across these different scenarios.

Education Composition of Immigrants. Our baseline exercise uses the hypothesis that the education composition of new immigration is the same as the one observed in 2019. Differences in education composition change the total net benefits on immigration. In Appendix E.4, we show, however, that the rebalancing tax increase still exhibits decreasing returns with respect to the net immigration flows, when the all immigrants have completed tertiary education or all immigration have only completed primary education.

5 Rebalancing Tax Increases at the Country Level

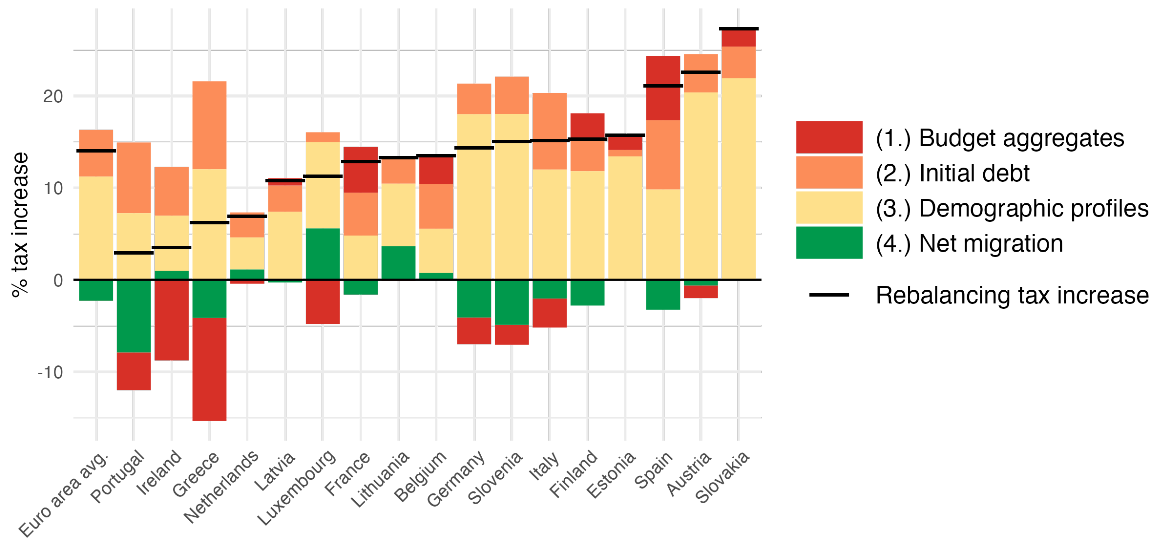
Up until this point, all the results reported are for the Euro area aggregate. This masks substantial differences across countries. We now compute the rebalancing tax increase for each country of the EA.

In Figure 7, the solid black line reports the country-specific rebalancing tax increase. The value is computed using the estimated demographic profile of the government budget, the demographic projections, and the current level of migration, that is assumed to be sustained, of each country. Countries like Austria and Slovakia have the most unbalanced public finance situation and would need a permanent increase in taxes of 22.6 percent and 27.3 percent, respectively. On the other hand, Ireland and Portugal are the countries with the smallest rebalancing tax increase.

To understand what is behind the observed differences across countries, we decompose their rebalancing tax increase metrics, calculating the contribution of the initial debt, the initial aggregate fiscal imbalance, the demographic structure of the budget and migration. For that, we recompute the rebalancing tax increase holding different components fixed. This yields the contribution of different factors to the metric. Figure 7 shows the results of this decomposition for each country and for the EA average. We proceed in four steps, leading up to the baseline θ_τ.[29]

[28] Across these scenarios we keep the assumption that 2nd-generation immigrants have the same fertility as natives.
[29] In Appendix C.5, we show the details of this decomposition.

Figure 7: Decomposition of the Rebalancing Tax Increase for EA Countries



Note: The figure reports the rebalancing tax increase, θ_τ, for the different countries of the EA and the EA average (solid black line). It also shows the decomposition of this metric in four components: initial debt, budget aggregates, demographic profiles and net migration.

We start with uniform demographic profiles – all individuals pay the same net taxes –, a balanced initial budget, and net migration equal to zero. The only source of imbalances in the IGBC – Equation (7) – is the initial debt, as the revenue collected matches the expenditure done in the same year. The rebalancing tax increase, in this case, gives only the contribution of the initial debt stock, which is always positive – it is the permanent tax increase that would be necessary to sustain the public debt, even if the budget was balanced.

Second, we change the budget aggregates to the observed values in the base year, while keeping uniform demographic profiles. The rebalancing tax increase, in this case, covers the initial public debt stock and the initial primary balance repeated over time. By difference with the previous, we obtain the contribution of the budget aggregates, which for some countries is positive and others negative.

Third, we reintroduce the demographic profiles from the data, where different age or education groups pay different net taxes. Now, the change in the age structure of the population affects the budget balance over time. The change in the θ_τ metric from this step gives the impact of demographic change on the rebalancing tax increase. For all countries, the impact on θ_τ is always positive: the current structure of government budgets in Europe is not prepared for an aging society.

Finally, we add the net migration flow, which changes population dynamics. This last step, which recovers the baseline θ_τ, except for a few countries, lowers the rebalancing tax increase. As discussed in the case of the EA aggregate, immigrants from outside the EU are younger than the resident population, smoothing the impact of aging on public finances.

Analyzing the decomposition of the rebalancing tax increase in the EA, the budget aggregates contribution has a negligible impact on θ_τ, given the nearly balanced primary deficit registered in 2019. The initial public debt stock contributes 5.1 percentage points to the rebalancing tax, while the demographic composition of the budget accounts for 11.2 percentage points. Additionally, net migration has a positive effect, reducing θ_τ by to 2.2 percentage points, as shown before.

The Figure allows for cross-country comparisons of the contribution of each factor. For instance, France and Germany have very similar overall rebalancing tax increases, however, the root causes are different. The impact of demographic change is more favorable in France, but the initial budget balance position is much worse, contributing almost one-third of the value of θ_τ. Germany, on the other hand, has a favorable initial fiscal position, but a very unprepared demographic structure of the budget, considering the aging trends it will face.

Additionally, the Figure also shows that net migration has different impacts on the rebalancing tax increase. Portugal and Slovenia are the countries that benefit the most from net migration, contrarily to Luxembourg or Lithuania where current migration has contributes to a larger rebalancing tax increase. The different impacts of migration across countries are a consequence of the diminishing returns of migration that we uncover in this paper. Countries have very different levels of net migration flows; hence changing this flow will also have very different impacts on public finances sustainability. In Appendix F.2, we show these effects for each country. Furthermore, this result highlights how challenging is to set a common migration policy within the European Union, since migration has heterogeneous impacts on public finances.

6 Conclusion

In this study, based on detailed data on taxes, benefits, and demographic dynamics, we revisited the question of how immigration can help relieve the fiscal burden of aging, focusing on the case of Europe. 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. The relation between immigration and fiscal balances is convex: boosting migration has diminishing benefits, while restricting migration would have increasing costs for public finances – these are the costs of building walls. This conclusion is underpinned by a novel theoretical analysis of the stable population and transition properties of population models featuring constant immigration flows, along with our empirical application to European data.

Specifically, we show that cutting migration flows down to zero increases the fiscal burden of aging, measured by the necessary rebalancing tax increase, by 2.3 percentage points compared to our baseline of 14%. This means that shutting down migration would require Euro area countries to, on average, impose an additional tax burden increase of 1 percent of the GDP, every year, to deal with the fiscal burden of aging.

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.

Furthermore, the rebalancing tax increases vary significantly across countries, due to differing demographic factors and initial fiscal conditions. Net migration alleviates the fiscal burden of aging in some countries, while its impact is minimal or even negative in others. These findings suggest additional challenges to finding an agreement between countries for a EU-wide migration policy.

Our analysis uncovers novel facts informing current policy discussions. Migration policy has taken center stage in Europe: as many European countries experience an increase in political polarization, some proposals are pushing towards curbing immigration. Our findings make it clear that restrictions on immigration flows from developing countries may significantly increase the net tax burden on natives. This is due to the strong 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 Stylized Demographic Model Simulations

The simplified model considered in subsection 2.2 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.

Population is composed 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. There are two separate groups, Native and Foreign, indexed by i.

Immigrants enter the population as adults, capturing the feature of the data that most immigrants from outside the EU are of working ages.[30] There is an exogenous flow of immigrants, a constant absolute value M, in keeping with our full model and typical assumptions in the literature. The offspring of immigrants enter the foreign young population.

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

$$\begin{aligned} P^i_{o,t} &= (1-\pi_m)P^i_{o,t-1} + \pi_o P^i_{a,t-1} \\ P^i_{a,t} &= (1-\pi_o)P^i_{a,t-1} + \pi_a P^i_{y,t-1} + I.\mathbf{1}\{i=F\} \\ P^i_{y,t} &= (1-\pi_a)P^i_{y,t-1} + f^i P^i_{a,t-1}. \end{aligned} \tag{10}$$

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 is equivalent to a model where individuals spend a certain amount of periods in "young", "adult" and "old" life cycle stages, as long as the parameters are constant in each year of each life cycle stage.

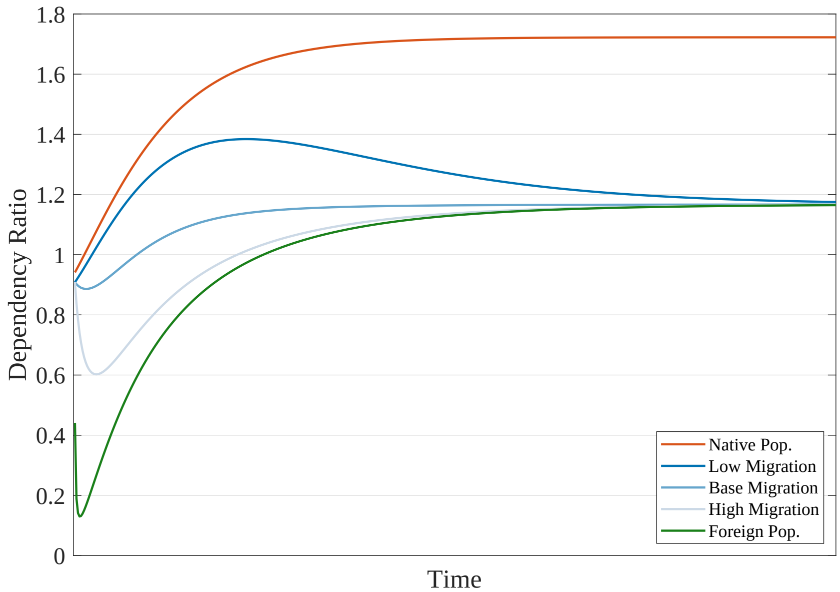
Simulation Results We provide an example of these dynamics by simulating the model above. The calibration does not intend to reproduce any specific country but reflects the facts, observed in most European countries, that the fertility rate of the native adults is below replacement, while that of the 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 65%.

We examine the transition of the dependency ratio under three intensities of immigration: low, medium and high. Figure 8 plots the dependency ratio along the transition for the different scenarios.

[30] Figure 1 illustrates this pattern.

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

Figure 8: Dependency Ratio Along the Demographic Transition



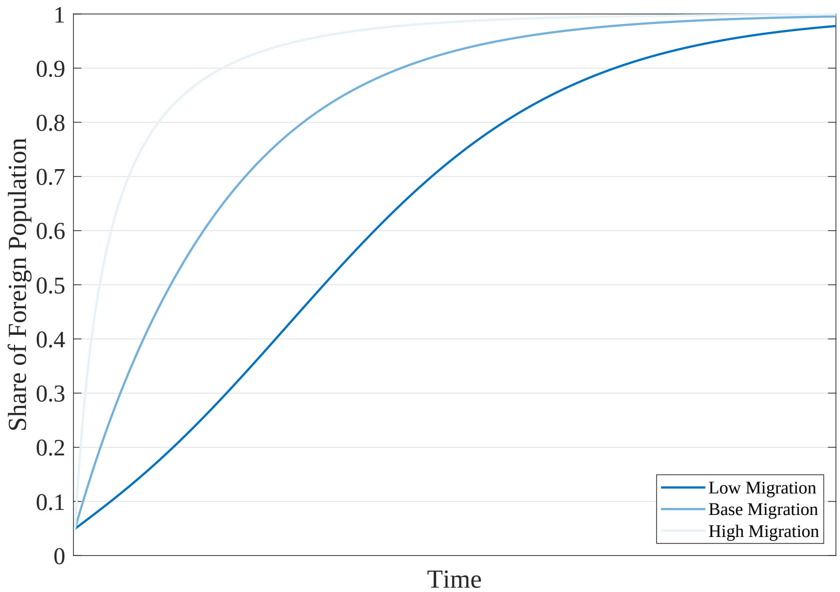
Note: The dependency ratio is the quotient between the young and old population over the adult population. This Figure plots this ratio of the native population (red), foreign population (green) and of the total population for different immigration intensities (shades of blue).

Figure 8 illustrates, first, the stable population results described above. Regardless of the intensity of immigration flows, the long-run dependency ratio of the population converges to that of the Foreign group. Without immigration, then the long-run dependency ratio would be equal to that of the native group which is substantially higher.

We now look at the transition from an initial population where the initial dependency ratio is below its steady-state level, as in the data. We also plot the share of foreign population over time in the projection, in Figure 9. The overall picture can be interpreted as follows. As the share of immigrants increases over time, the dependency ratio becomes closer to the immigrant group's and farther from the native group. At low levels of immigration, the population dependency ratio first follows similar dynamics to the native group, as the share of immigrants is low for several periods. With higher levels of immigration, instead the share of immigrants quickly rises and, as such, the dependency ratio of the population quickly jumps to the transition path of the immigrant group. Figure 8 also shows that, for any given period, the share of immigrants increases non-linearly with the intensity of immigration flows, as it is converging to 1.

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, increasing immigration flows improves the dependency ratio along the transition, but at a decreasing rate.

Figure 9: Dependency Ratio Along the Demographic Transition



Note: The dependency ratio is the quotient between the young and old population over the adult population. This Figure plots this ratio of the native population (red), foreign population (green) and of the total population for different immigration intensities (shades of blue).

B 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.

B.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:

$$\Psi_t = \Psi_{\bar{t}} \prod_{j=\bar{t}+1}^{t} (1+\gamma_j)(1+\pi_j), \text{ for } t > \bar{t}. \tag{11}$$

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.

B.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:

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

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

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

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

B.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 $\left\{\mathcal{T}^{IRS}_x\right\}$. 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:

$$T_t = \sum_i T^i_t = \sum_{x\in X}\begin{bmatrix} \mathcal{T}^{IRS}_x\left(y^l_{t,x} + y^k_{t,x} + g^{unemp}_{t,x} + g^{sick}_{t,x} + g^p_{t,x}\right) \\ +\mathcal{T}^K y^k_{t,x} + \mathcal{T}^{VAT} y^l_{t,x} c_x \\ +\mathcal{T}^{SS} y^l_{t,x} + \mathcal{T}^H h_{t,x} + \mathcal{T}^u \end{bmatrix} P_{t,x} \tag{12}$$

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

$$g^i_{t,x} = \Gamma^i y^l_{t,x},\ i = \text{unemp, sick, p}$$

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

$$g^i_{t,x} = \Gamma^i_x \Psi_{\bar{t}} \Pi_t,\ i = \text{educ, health, PG}$$

where Γ^i_x 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:

$$G_t = \sum_i G^i_t = \sum_{x\in X}\begin{bmatrix} g^{unemp}_{t,x} & +g^p_{t,x} & +g^{sick}_{t,x} \\ +g^{health}_{t,x} & +g^{educ}_{t,x} & +g^{PG}_{t,x} \end{bmatrix} P_{t,x} \tag{13}$$

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.

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.

C Methodological Details

C.1 Additional Adjustments to Tax and Benefit Macro Values

C.1.1 Cyclically-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:

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

where $T^i_{\bar{t}}$ is the observed value of the revenue item i in the base year, $Y^*_{\bar{t}}$ is the potential GDP of the year $\bar{t}$, $Y_{\bar{t}}$ is the observed value of GDP in year $\bar{t}$ and $\varepsilon_{i,Y}$ is the elasticity of revenue category i with respect to the output gap. We compute the 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 8 we describe the sources of the elasticities numbers that we use, as well as the source of the potential GDP.

C.1.2 Clemens (2022) Adjustment for Capital Income Taxes

Standard partial-equilibrium fiscal accounting omits an important channel: when a firm hires an immigrant, profit maximization requires the firm to also employ additional capital. This additional capital generates capital income—and hence additional tax revenue—which is omitted when only the labor income taxes are considered. Following Clemens (2022) we adjust our estimates by including a conservative measure of the capital income taxes induced by immigrant employment.

For each country, we adjust the baseline revenue per capita attributed to new immigrants, i.e. additional immigrants entering the population after the base year 2019, by a component given by the following expression for demographic group x:

$$\Delta\tau_x^{\kappa} = \left(\tau_x^{PIT} + \tau_x^{SS}\right) \times \left(\frac{\mathcal{T}^{\kappa}}{\mathcal{T}_{k(x)}^{L}}\right) \times \frac{\alpha}{1-\alpha} \times \omega,$$

where $\mathcal{T}^{\kappa}$ denotes the tax wedge on capital income and $\mathcal{T}^{\mathcal{L}}$ on labor income (for education level k) respectively, α is the aggregate capital share of income, and ω is the share of capital owned by natives. The adjustment is performed at the country level. Data for $\mathcal{T}^{\mathcal{L}}{}_k$ are obtained from the OECD Taxing Wages 2024 report[32], while data for $\mathcal{T}^{\kappa}$ come from the Taxation Trends in Europe 2020 report by the European Commission. α, the capital share of income, is calculated as one minus the labor share of income, computed from Eurostat national accounts for the same year, as the ratio of total compensation of employees (wages and salaries plus employers' social contributions) to gross value added in each country.

We also introduce a scaling factor due to the differences in the firm and property ownership between natives and immigrants. The fraction of corporate shares owned by immigrants is smaller than natives, thus it would be unreasonable for both groups to have the same corporate income tax demographic profile. We introduce an adjustment that takes into account these differences in the firm ownership rates that in practice allocates the burden of CIT mostly to the native group.

C.2 The AGK Imbalance Factor

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 also compute the AGK Imbalance Factor used in the GA literature. In this Appendix, we provide the formula using our notation. This metric was initially developed in the seminal work of Auerbach et al. (1991) and 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

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

[32] The database provides labor tax wedges for three income groups: 2/3 of the average income, average income level, and 2/3 above average. We attribute these, respectively, to primary, secondary and tertiary level of education workers.

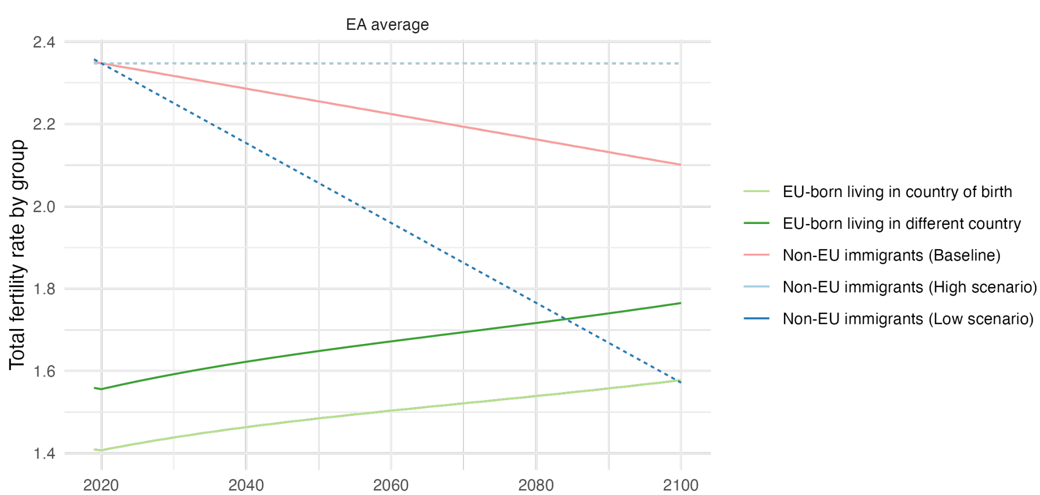
C.3 Building Population Projections

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, education, and birthplace for 2019-2100. After 2100 we assume a fully stationary population.

Fertility and Mortality The mortality rate used is the same across education level and country of birth and only differs by age and gender.[33] 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. The time path of these total fertility rate assumptions is shown in Figure 10, which additionally shows the fertility rates used for the robustness check scenarios described in Appendix E.3.

Figure 10: Assumptions for the time path of fertility rates by country of birth group



Note: The plot shows the fertility rate path by country of birth group used in the demographic projections. The sourceof the EU-born population path is the Eurostat EUROPOP demographic projections. The Non-EU-born path is an assumption that we do and that and test for the sensibility of it with a high fertility scenario (where we assume it to be constant and equal to value observed in 2019) and a low fertility scenario (where we assume a linear convergent trajectory towards the projected value for natives in 2100).

[33]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.

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.

Education We also split the population by education level. Data on education and country of birth compositions by age group is available for 2019. We build a future path for the education distribution using the education 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, education 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 education distribution as the natives.

These assumptions imply that, during the projection period, the education distribution converges to a stationary distribution. In that stationary state, the low-educated group share in the working-age population is smaller than in the base period and, conversely, the medium and high-education working-age population share is higher. Our education 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 education distributions for public finances, we stick with our conservative projection on the education level evolution. Furthermore, significant changes to the education distribution have implications for productivity growth, with second-order effects on taxes and benefits possibly requiring a general equilibrium analysis.

C.4 Estimation of the Demographic Profiles

Taxes and Social Benefits The demographic profiles for all budget items except education and healthcare are estimated through Equation (9) using the EU-SILC and the EU-HBS, provided by the Eurostat, as well as the HFCS provided by the ECB. However, not all budget items and variables are available for all countries. Moreover, some countries have small samples that does not allow us to estimate for all demographic groups. Here we list the deviations we do for the different countries and budget items:

- The demographic profiles of Estonia, Latvia and Lithuania are joint estimated. Arguably, these countries share many common features that makes the benefits of increasing the statistical power of joining the countries outweigh the issues of losing this heterogeneity.
- For all countries, the profiles of the primary and the secondary education levels are joint estimated.
- Spain does not report the country of birth of the individuals. Hence, Spanish demographic profiles use the European average differences between countries of birth.

- The VAT demographic profile of Austria and the Netherlands do not have education differences

Education and Healthcare We derive an age profile of education spending based on Eurostat data that has the government spending by level of studies. We allocate the spending to the expected age that an individual attends each level of study according to the report by Motiejunaite-Schulmeister et al. (2022). We do not consider any heterogeneity in terms of gender, education, 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.5 Decomposition of the Rebalancing Tax Increase

Recall the expression of the rebalancing tax increase

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

where we make explicit that population is a function of fertility, f, mortality, m, and net migration, M. We compute successive values of the rebalancing tax increase under different assumptions of the macro aggregates, profiles and population such that we get the contributions of the initial public debt, the initial primary balance, the demographic profiles, and net migration.

Define $\tau_{\bar{t}} \equiv \Sigma_i \Sigma_x \tau^i_{\bar{t},x}$ and likewise for g. Then,

1. Contribution of initial debt. Set $g^*_{\bar{t}} = \tau_{\bar{t}}$, such that the budget is balanced.

$$\sum_{s=0}^{\infty}\sum_{x\in X} D^s \left[g^*_{\bar{t}} - (1+\theta^{debt})\tau_{\bar{t}}\right] P_{\bar{t},x}\left(f,m,0\right) + B = 0$$

2. Contribution of the initial deficit.

$$\sum_{s=0}^{\infty}\sum_{x\in X} D^s \left[g_{\bar{t}} - (1+\theta^{debt}+\theta^{fiscal})\tau_{\bar{t}}\right] P_{\bar{t},x}\,(f,m,0) + B = 0$$

3. Contribution of the demographic profiles.

$$\sum_{s=0}^{\infty}\sum_{i}\sum_{x\in X} D^s \left[g^{i}_{\bar{t},x} - (1+\theta^{debt}+\theta^{fiscal}+\theta^{dem})\tau^{i}_{\bar{t},x}\right] P_{\bar{t}+s,x}\,(f,m,0) + B = 0$$

4. Contribution of the net migration.

$$\sum_{s=0}^{\infty}\sum_{i}\sum_{x\in X} D^s \left[g^{i}_{\bar{t},x} - (1+\theta^{debt}+\theta^{fiscal}+\theta^{dem}+\theta^{M})\tau^{i}_{\bar{t},x}\right] P_{\bar{t}+s,x}\,(f,m,M) + B = 0$$

D Additional Data Sources Details

D.1 Microdata Sources

Table 7: Microdata Sources

Tax/benefit	Source	Micro data variables used for distribution
PIT	EU-SILC	Income taxes (HY140G)
Property tax	HFCS - wave 3	Real estate holdings (DA1400)
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 8: 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.[34] Table 9 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 9: Imbalance Metrics under Different Macroeconomic Assumptions

Macro Scenario	θ_τ	θ_τ^{AGK}
Baseline	14.0%	28.3%
$\gamma = 0$	14.2%	39.3%
$\gamma = r$	14.9%	14.9%

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.

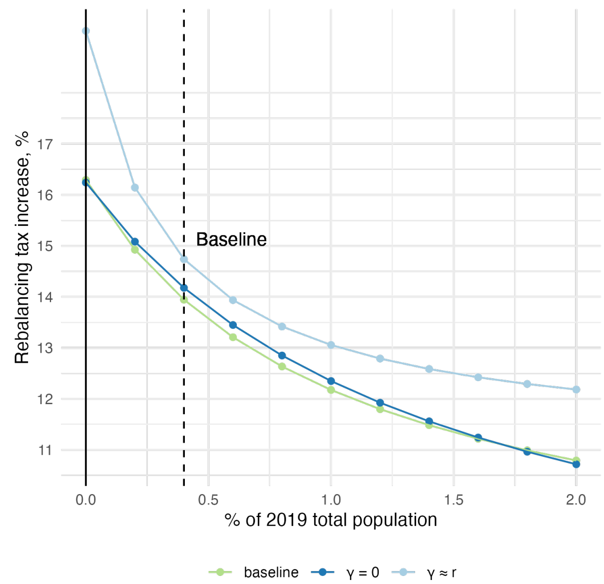
To see that the macroeconomic hypotheses do not play a role in the increasing costs on public finances of reducing migration, we also recompute the frontier between the rebalancing tax increase and the immigration level. It follows from the fact that D has a minimal influence on θ_τ that it also does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

E.2 Immigrants Offspring Fertility

In the baseline scenario, we assume that the immigrants offspring fertility is equal to the fertility of the native population. In this robustness exercise, we show that the nonlinearity result does not

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

Figure 11: 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.

depend on this assumption. For that we consider the case where the descendants of the immigrants keep the same fertility parameters as their parents. In Table 10 we report the imbalance metrics for the alternative offspring fertility assumption.

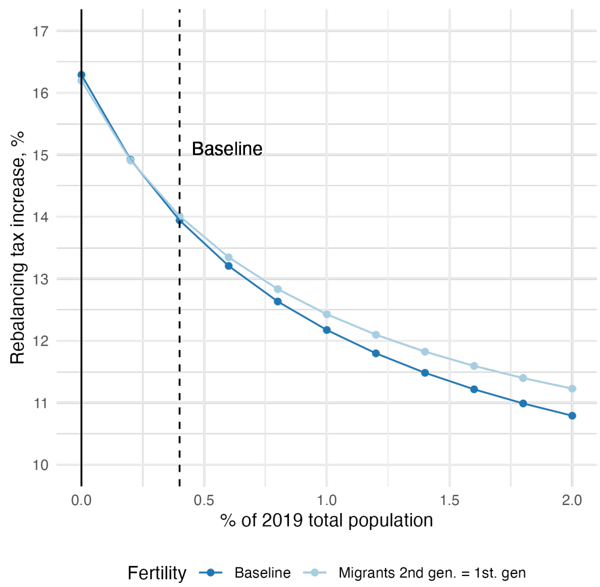
Table 10: Imbalance Metrics under Different Assumptions for Immigrants' Offspring Fertility

Offspring Fertility Scenario	θ_τ	θ_τ^{AGK}
Native (baseline)	14.0%	28.3%
1st generation	14.1%	27.5%

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.

The difference in the rebalancing tax increase between the two scenarios is 0.1 percentage points, and for the θ^{AGK} is 0.8 percentages points. This illustrates that our baseline results are robust to the immigrants offspring fertility rate hypothesis. Figure 12 shows the frontier between the level of immigration and the rebalancing tax increase. The convex relationship between the two remains under the alternative assumption.

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



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.

E.3 Immigrants Fertility

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

These scenarios are illustrated in the time path for the total fertility rate, shown in Figure 10 (see Appendix C.3).

We then, recompute the rebalancing tax increase. Table 11 shows this metric together with the θ_τ^{AGK} and the IBG. The differences are quite small across fertility scenarios. 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.

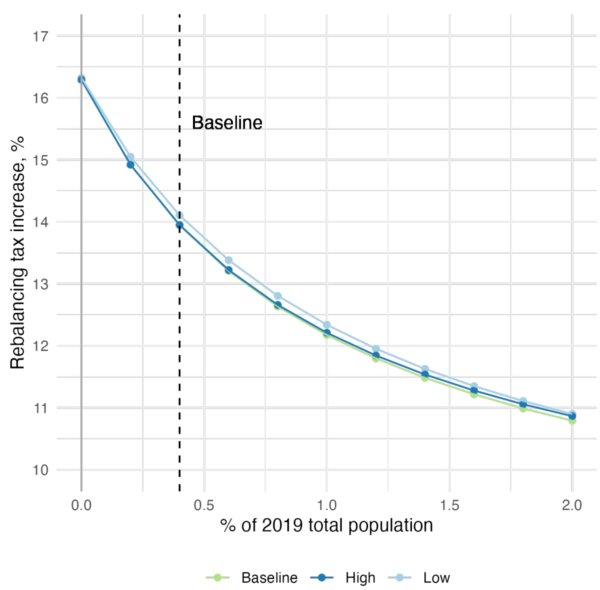
Table 11: Imbalance Metrics under Different Non-EU Immigrant Fertility Rates

Immigrants Fertility Scenario	θ_τ	θ_τ^{AKG}
Baseline	14.0%	28.3%
High fertility	13.6%	55.4%
Low fertility	14.2%	29.8%

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 13 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 13: Frontier between the Level of Immigration and the Imbalance Factor for Different Immigrants' Fertility Hypotheses.



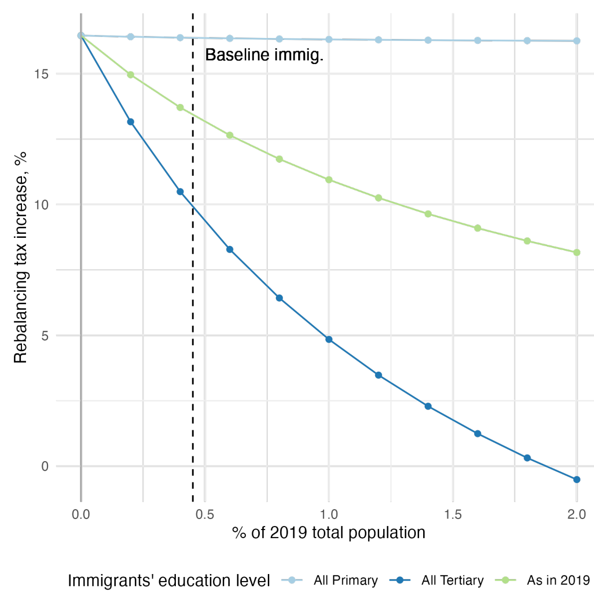
Note: The figure shows the weighted average θ_τ across countries using the 2019 potential GDP as weights, for the different net migration scenarios. θ_τ is computed according to Equation (8), scenarios of the non-EU born fertility rates. The dashed line is the baseline net migration value.

E.4 Immigrants Education Composition

In the baseline scenario, we assume that the education composition of new immigrants is constant and equal to the 2019 composition. In this appendix, we show that this hypothesis does not change our key result that the rebalancing tax increase have decreasing returns to immigration.

Figure 14 shows the frontier between the rebalancing tax increase and net migration for alternative, rather extreme, assumptions for the education composition of migration. The green line represents the baseline as in the main text, the light blue line represents the frontier if immigration consists only individuals with primary education, and the dark blue line represents the frontier when immigration consists only of individuals with higher (university) education.

Figure 14: Frontier between the Level of Immigration and the Imbalance Factor for Different Immigrants' Education Composition 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) for different hypothesis about the education composition of immigrants. The dashed line is the baseline net migration value.

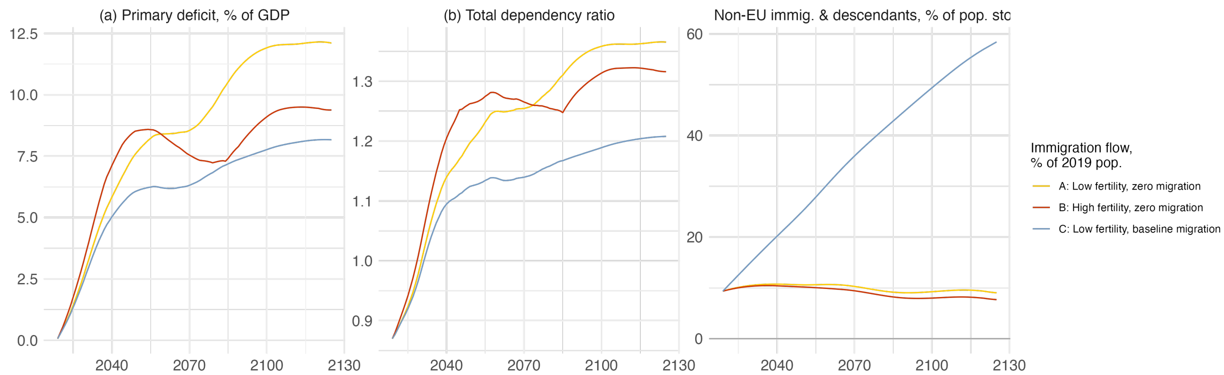
In all three cases, the frontier has a negative and convex shape, as described above. Recall that this means immigration lowers the rebalancing tax increase but at a decreasing rate. However, the convexity changes with the education composition of immigration. In the case where immigration consists only of low-educated population, the frontier is almost flat, indicating that more immigration does not significantly affect θ_τ, consistent with a lifetime net contribution of working-age, low-education immigrants close to zero. On the other hand, if immigration consists only of higher-educated individuals, the frontier between the size of immigration inflow and the rebalancing tax increase is steeper, with immigration bringing more positive effects for public finances.

Overall, these results highlight that, even with lower education levels than the resident population, non-EU immigrant flows can help relieve the fiscal burden of aging. The fiscal costs of building walls would be significant, and increasing, even if the education levels of non-EU immigrants were lower than at present.

F Additional Figures

F.1 Increasing the Native Fertility Rate

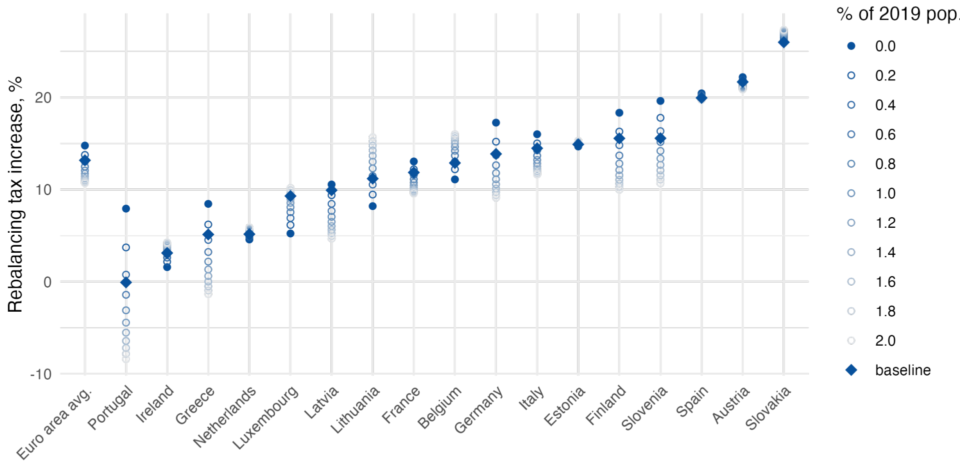
Figure 15: Primary Deficit and Demographic Dynamics under the Fertility Scenarios



Note: Panel (a) shows the projected primary deficit as a percentage of the potential GDP for the scenarios with low (baseline) and high fertility, labeled as in Table 6. Panel (b) plots the age-dependency ratio (computed as the sum of the young and old populations divided by the working-age population) for these same scenarios. Panel (c) shows the share of non-EU born and descendants in the population stock for the same net migration scenarios. Recall that scenario C corresponds to the baseline scenario in the main exercise.

F.2 Country-specific Rebalancing Tax Increase

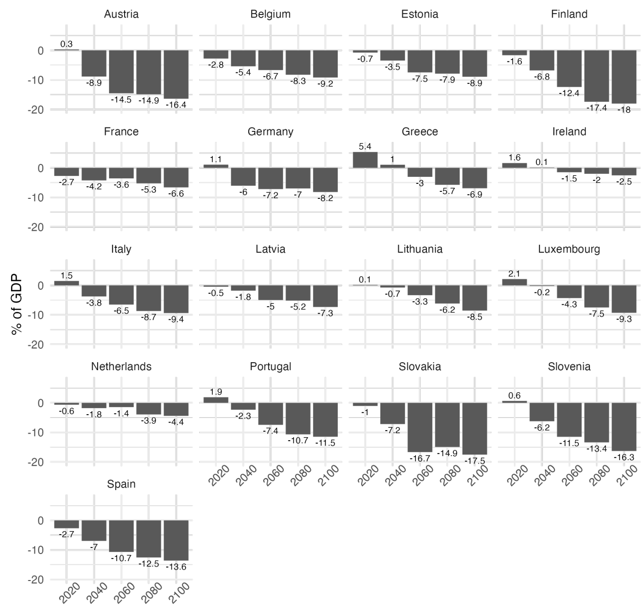
Figure 16: Rebalancing Tax Increase by EA country, θ_τ



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

F.3 Country-specific Primary Balance

Figure 17: Counterfactual Primary Balance implied by the Population Projections for the Different EA Countries.

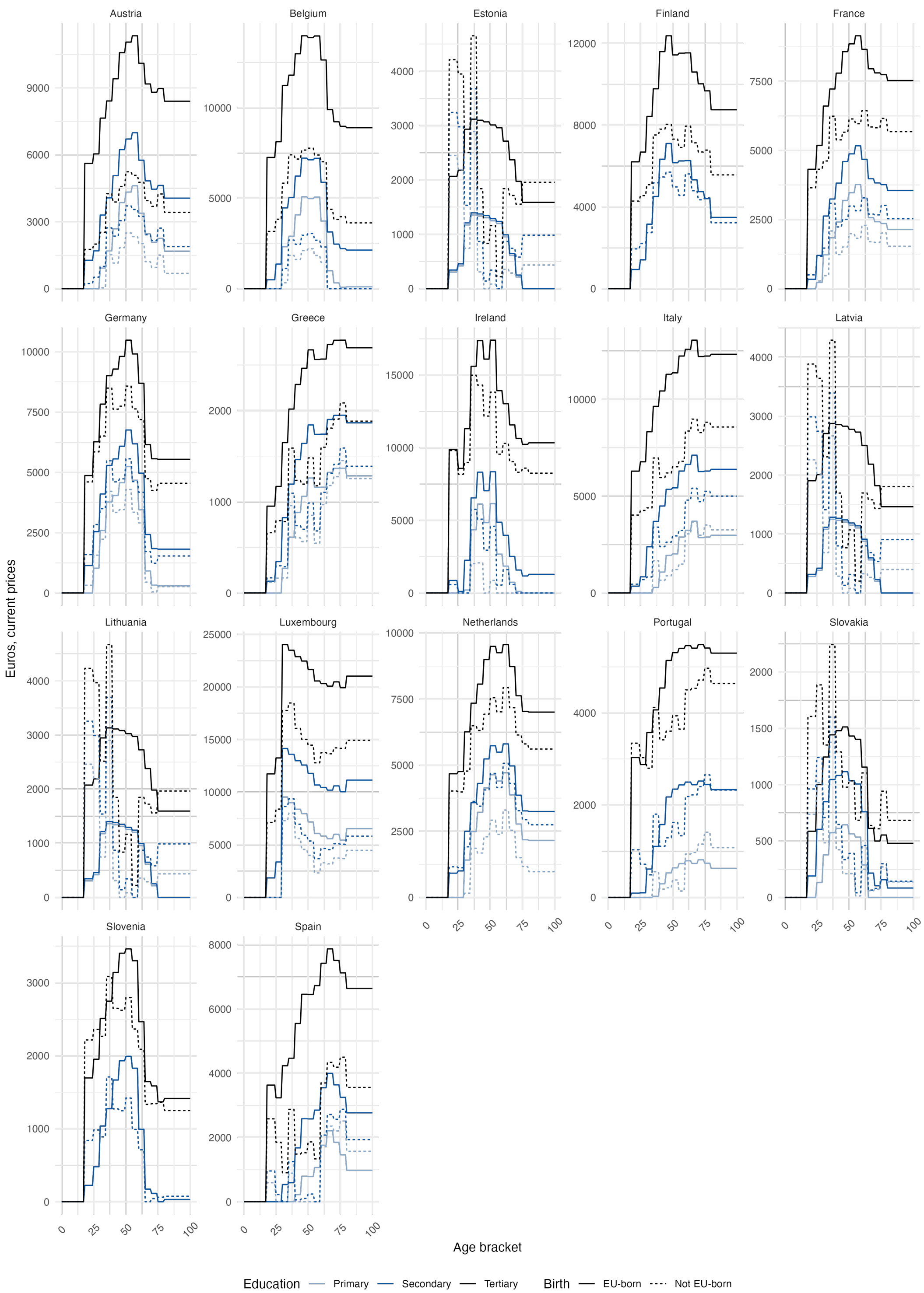


Note: The Figure shows the country-specific primary balance projection for selected years in percentage of the potential GDP.

F.4 Country-specific Estimations

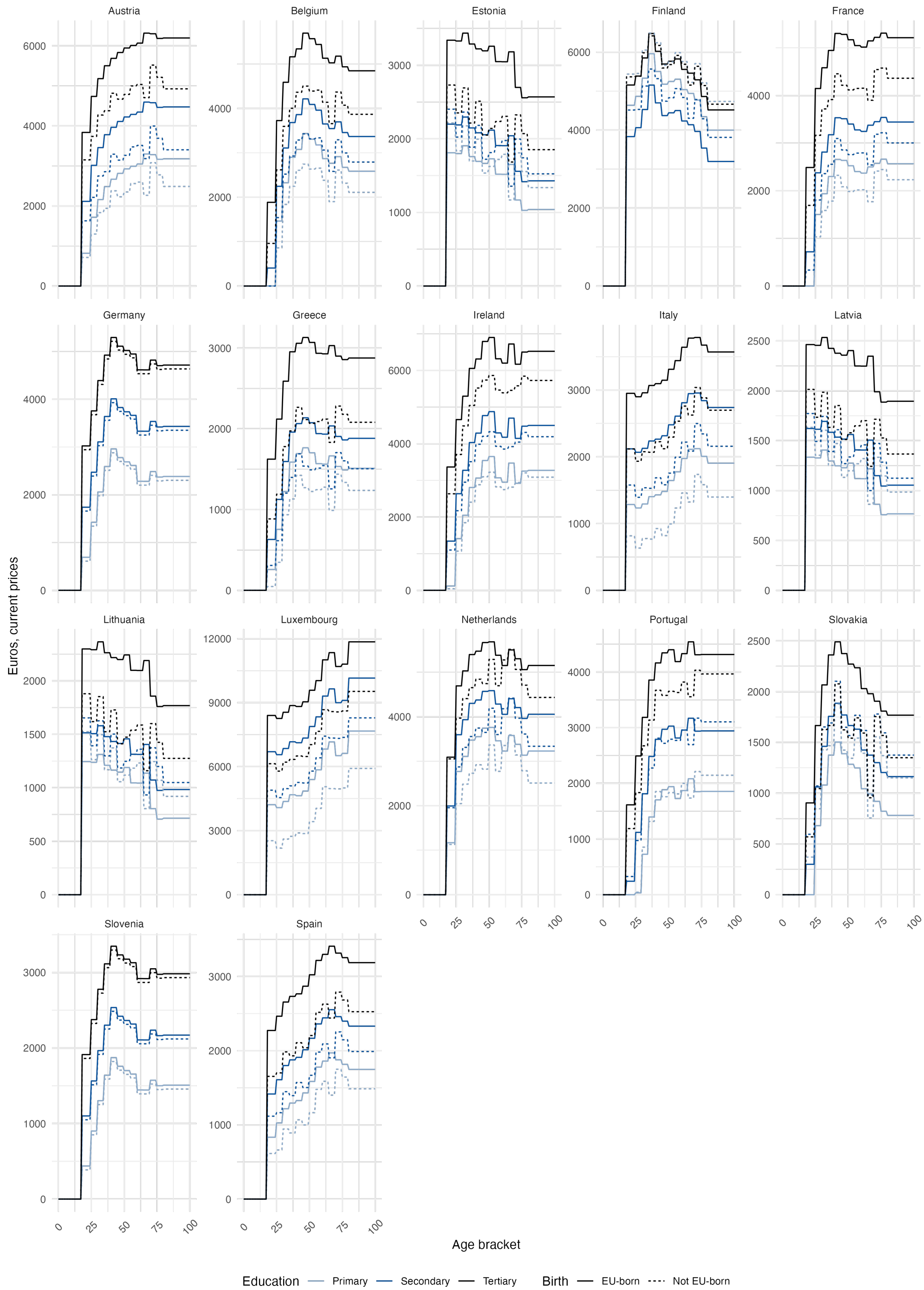
F.5 Other Figures

Figure 18: Demographic Profiles of Income Tax Payments



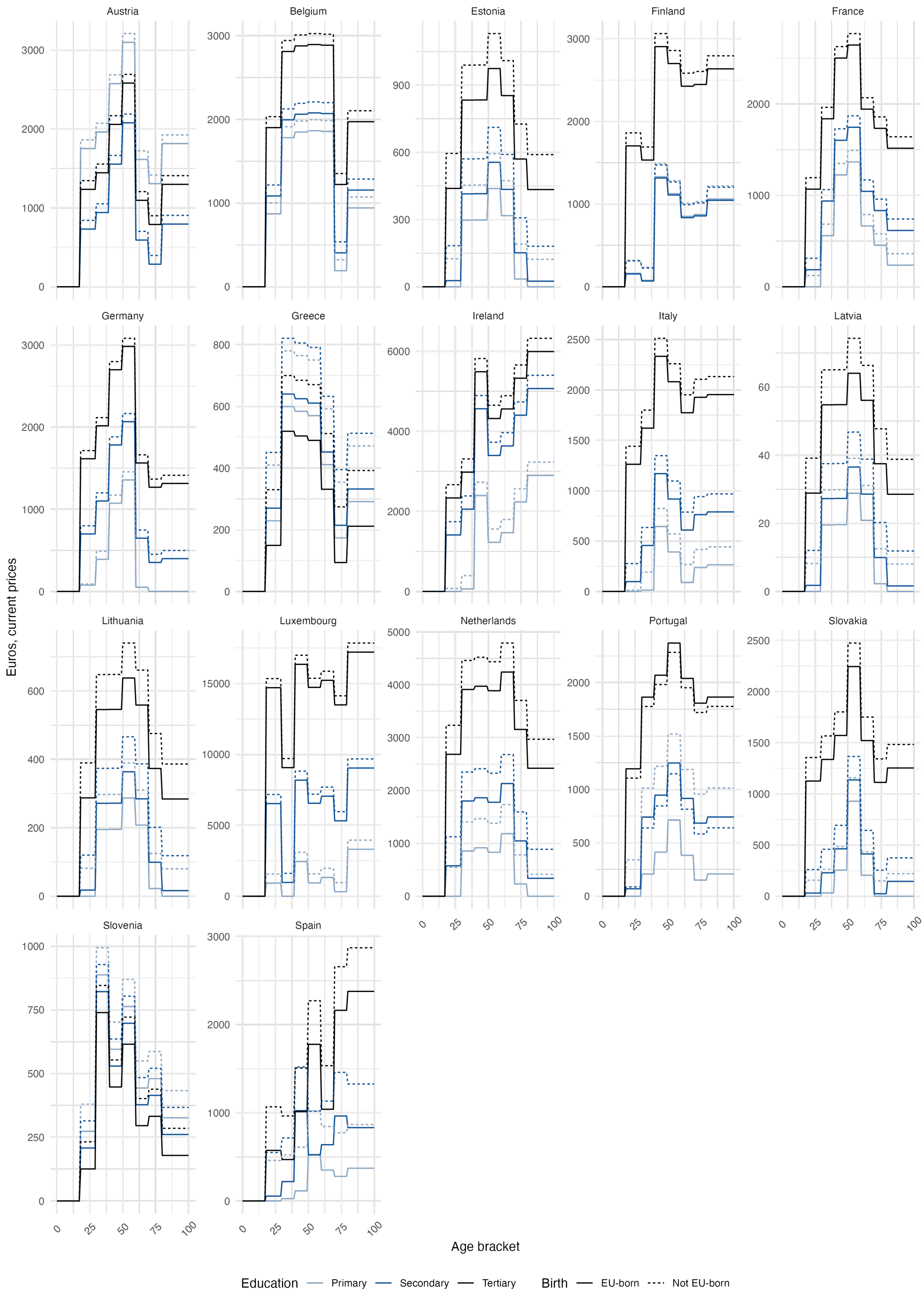
Note: Data from EU-SILC, 2019 wave on household-level income tax payments and Eurostat, assigned to household members in proportion to their respective share in the total household income. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 19: Demographic Profiles of Consumption



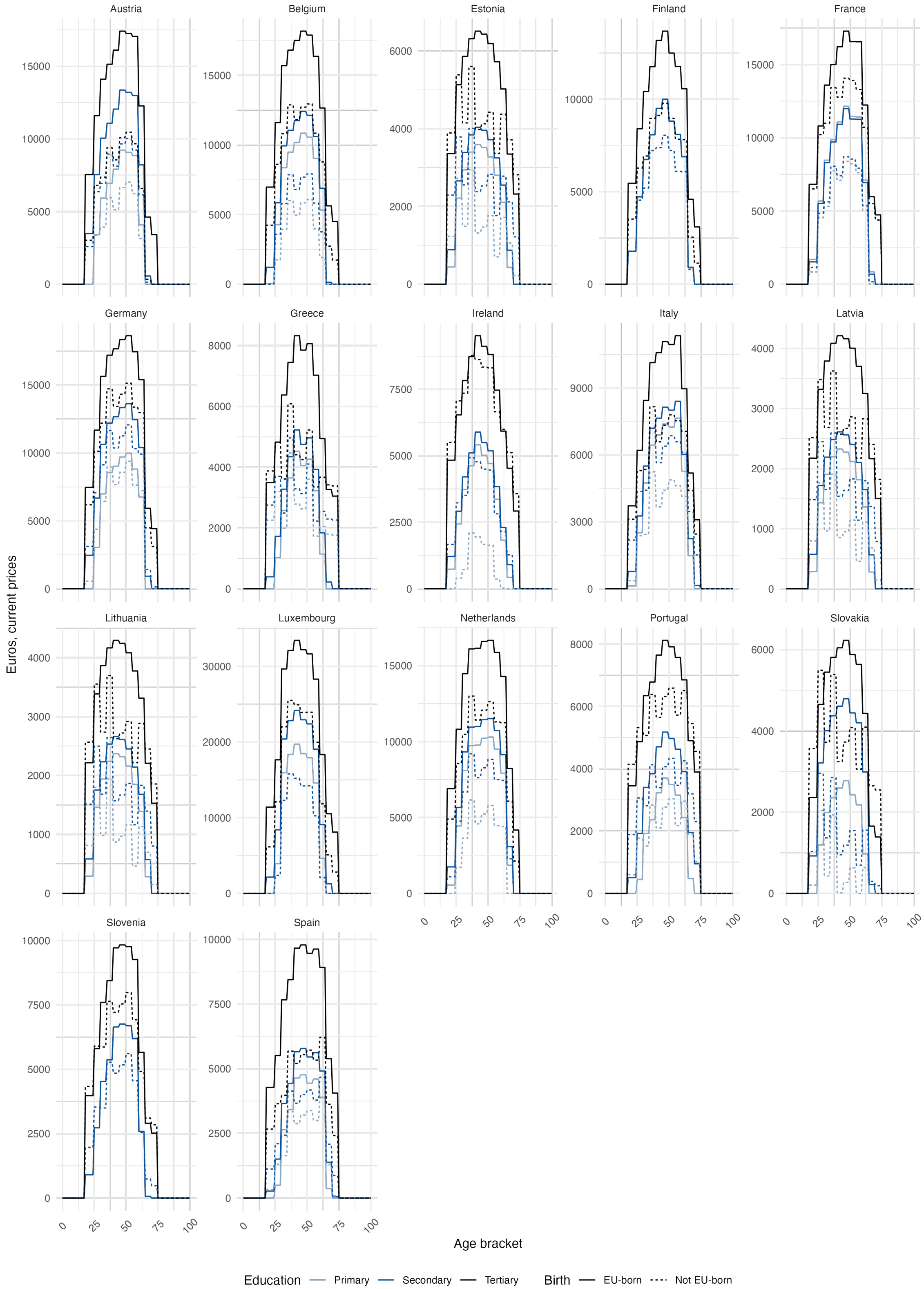
Note: Data from HBS, 2015 wave on household-level total consumption spending and Eurostat, assigned to household members in proportion to their respective share in the total household income. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 20: Demographic Profiles of Business Wealth



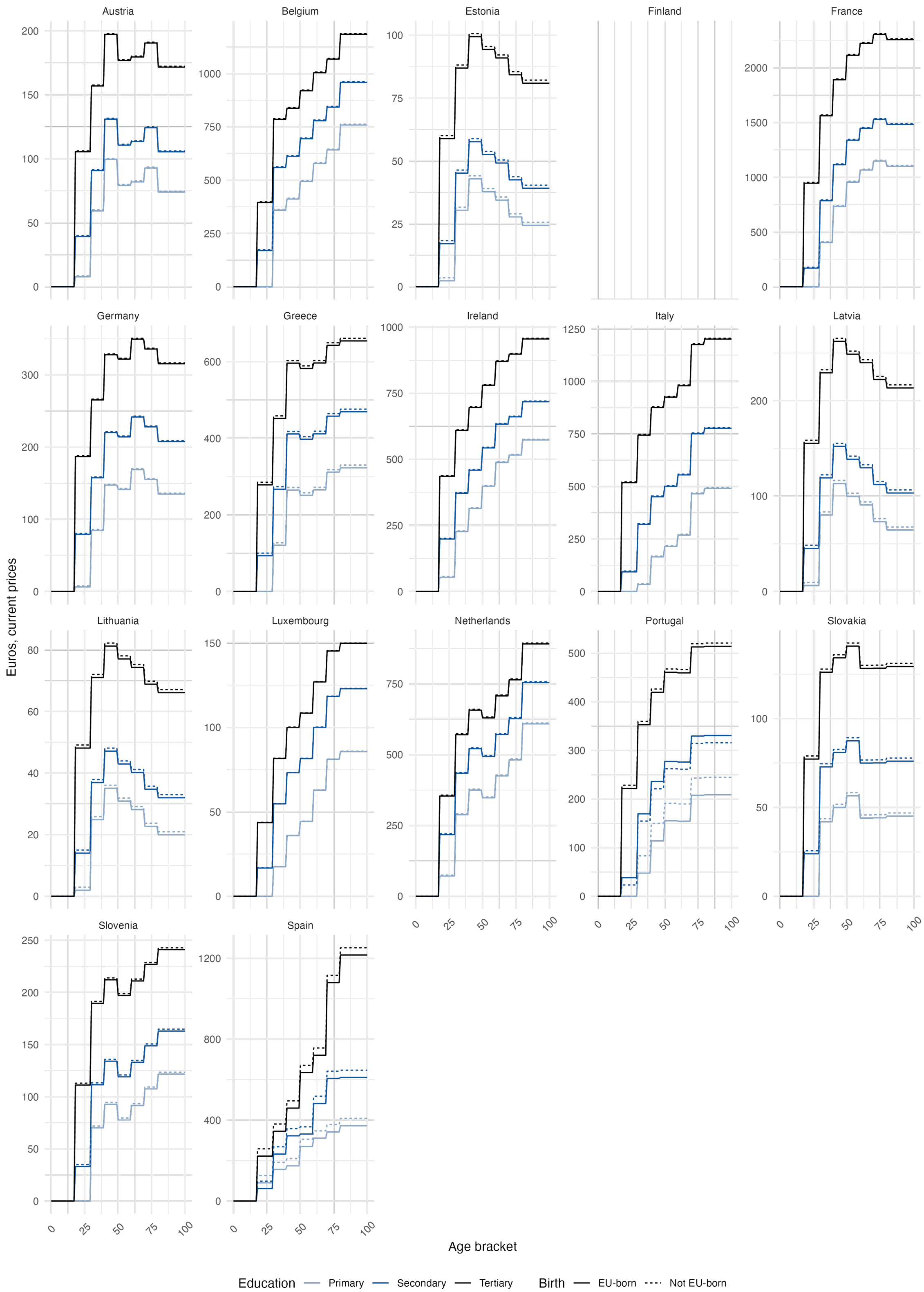
Note: Data from HFCS, 2017 wave on household-level business wealth holdings and Eurostat, equally split between adult household members. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 21: Demographic Profiles of Labor Income



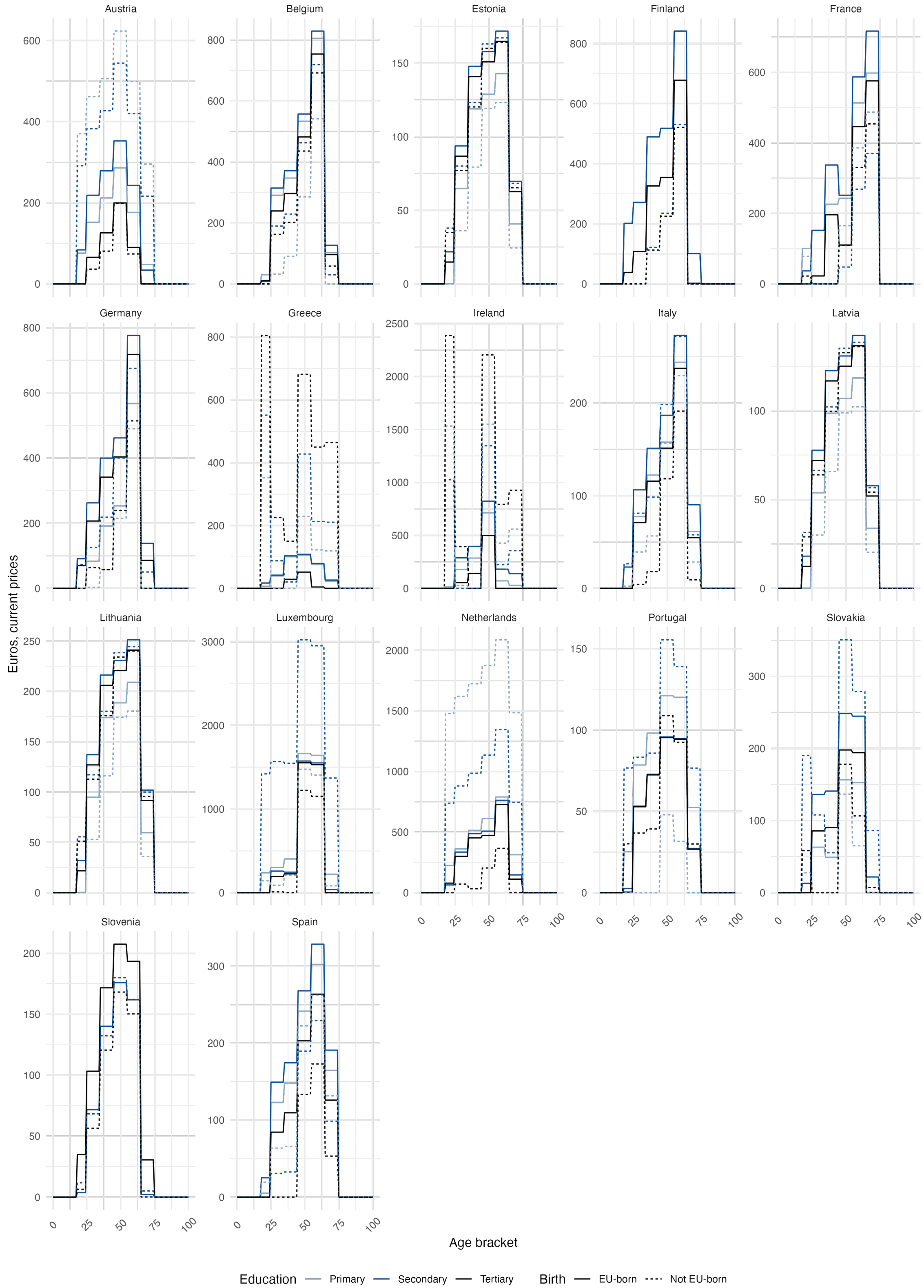
Note: Data from EU-SILC, 2019 wave on individual labor income and Eurostat. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 22: Demographic Profiles of Wealth Taxes



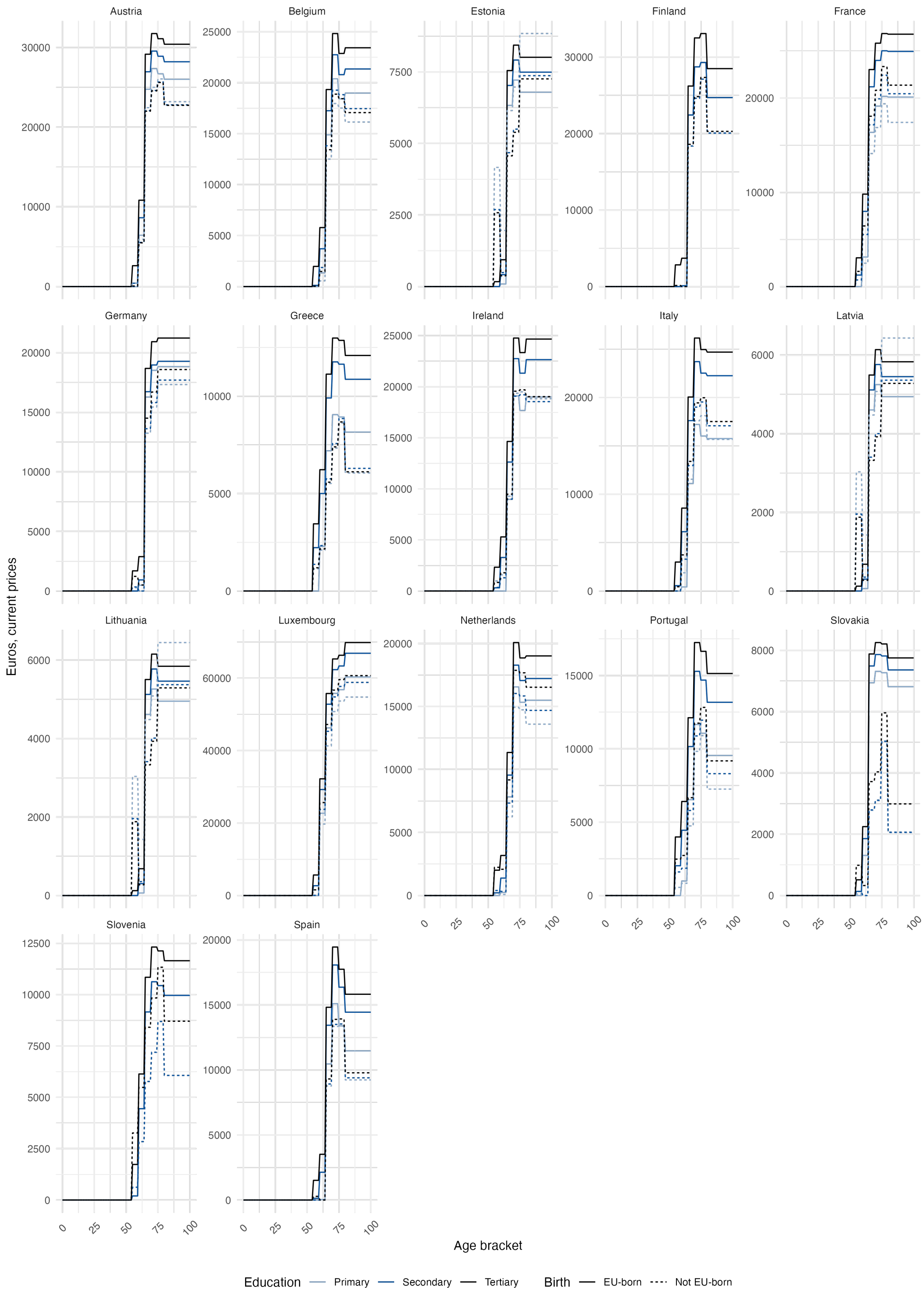
Note: Data from HFCS, 2017 wave on household-level real estate holdings and Eurostat, equally split between adult household members. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 23: Age Profiles of Sickness Allowance



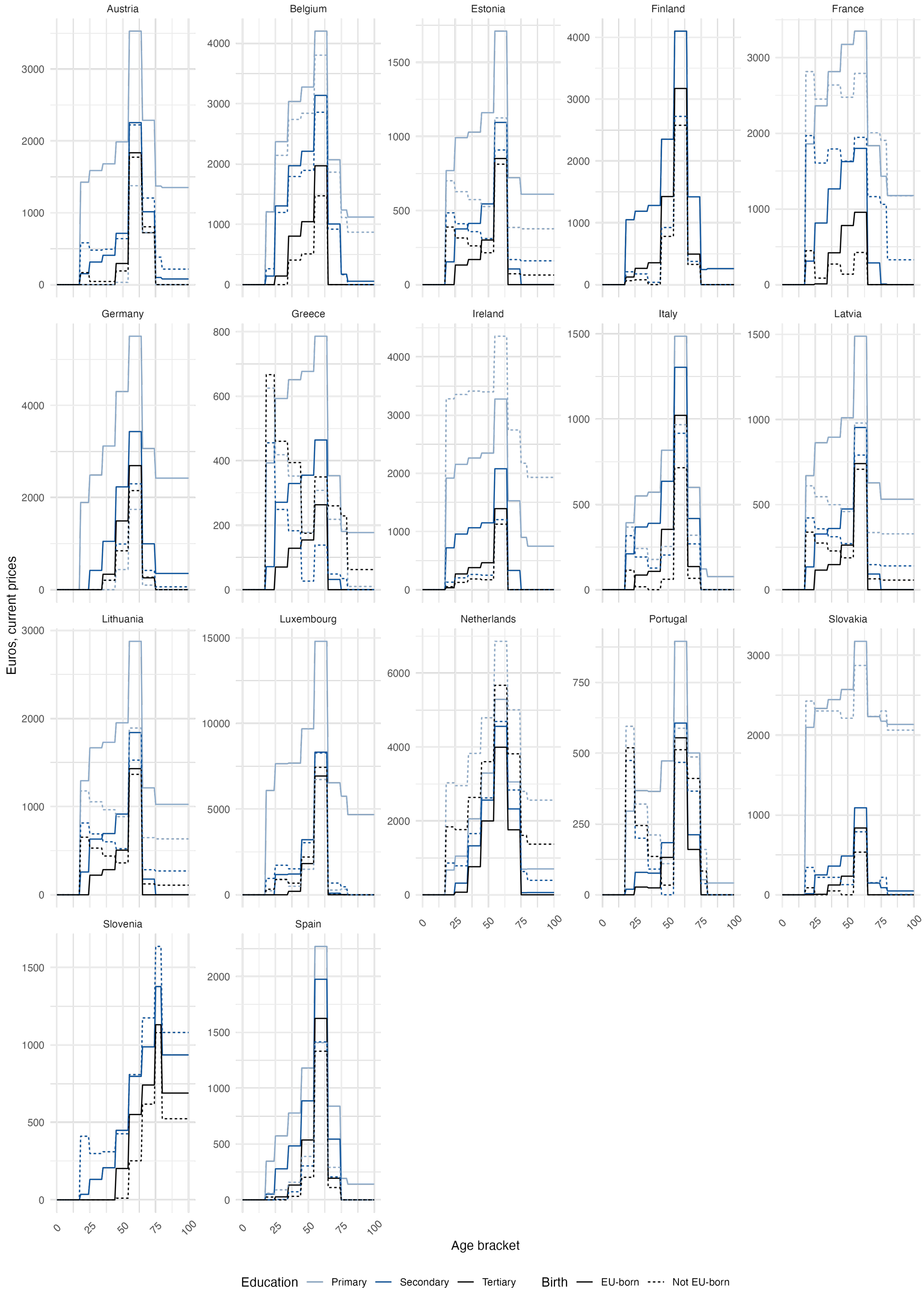
Note: Data from EU-SILC, 2019 wave on individual sickness benefits and Eurostat. Data is plotted for each country, age-bracket, education level and country of birth.

Figure 24: Demographic Profiles of Old-Age Pension



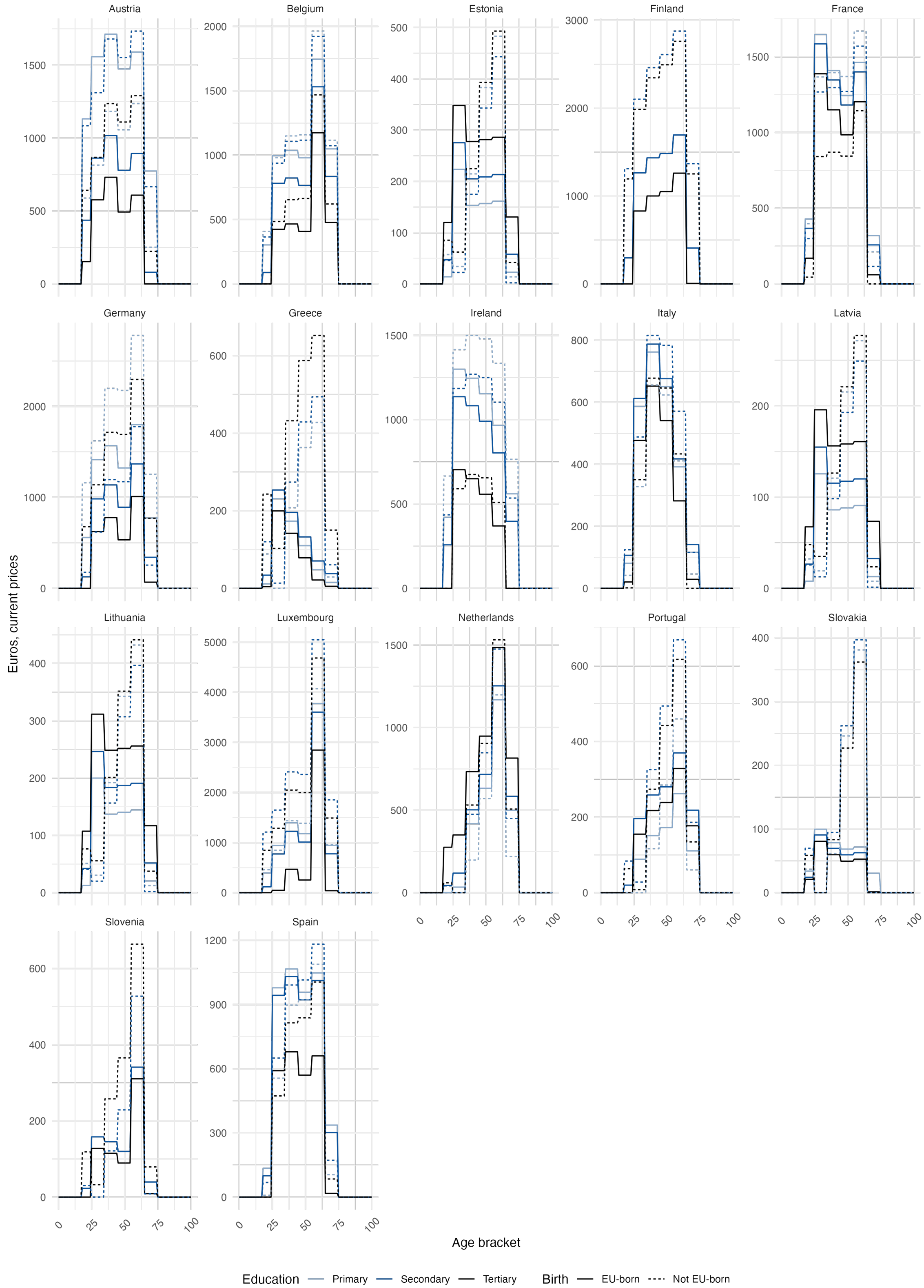
Note: Data from EU-SILC, 2019 wave on individual old-age benefits and Eurostat. Data is plotted for each country, age-bracket, education level and country of birth..

Figure 25: Demographic Profiles of Disability Benefits



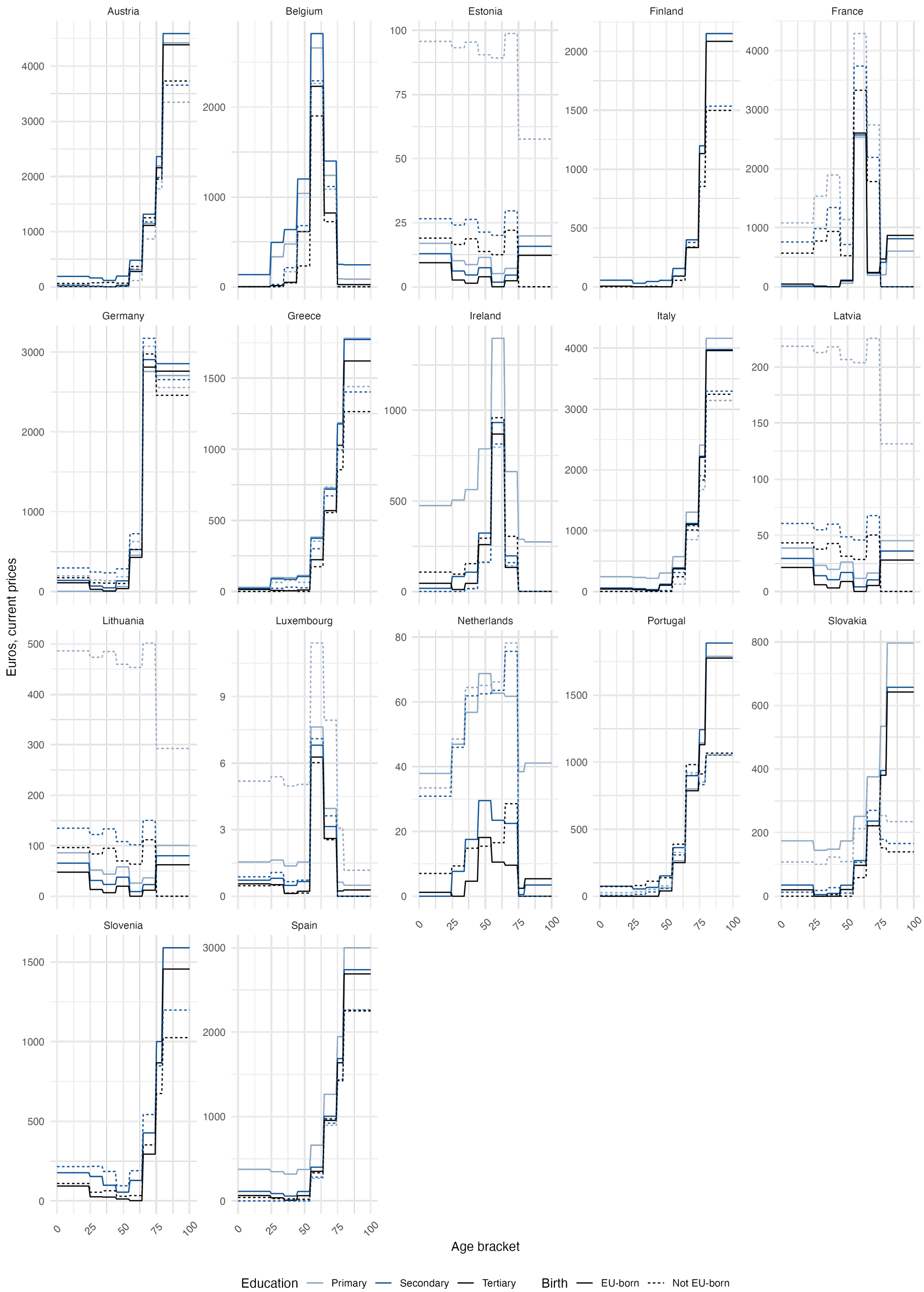
Note: Data from EU-SILC, 2019 wave on individual disability benefits and Eurostat.Data is plotted for each country, age-bracket, education level and country of birth..

Figure 26: Age Profiles of Unemployment Benefits



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

Figure 27: Age Profiles of Survivor Pension



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

Figure 28: Demographic profile of revenues and expenditures per capita, by country

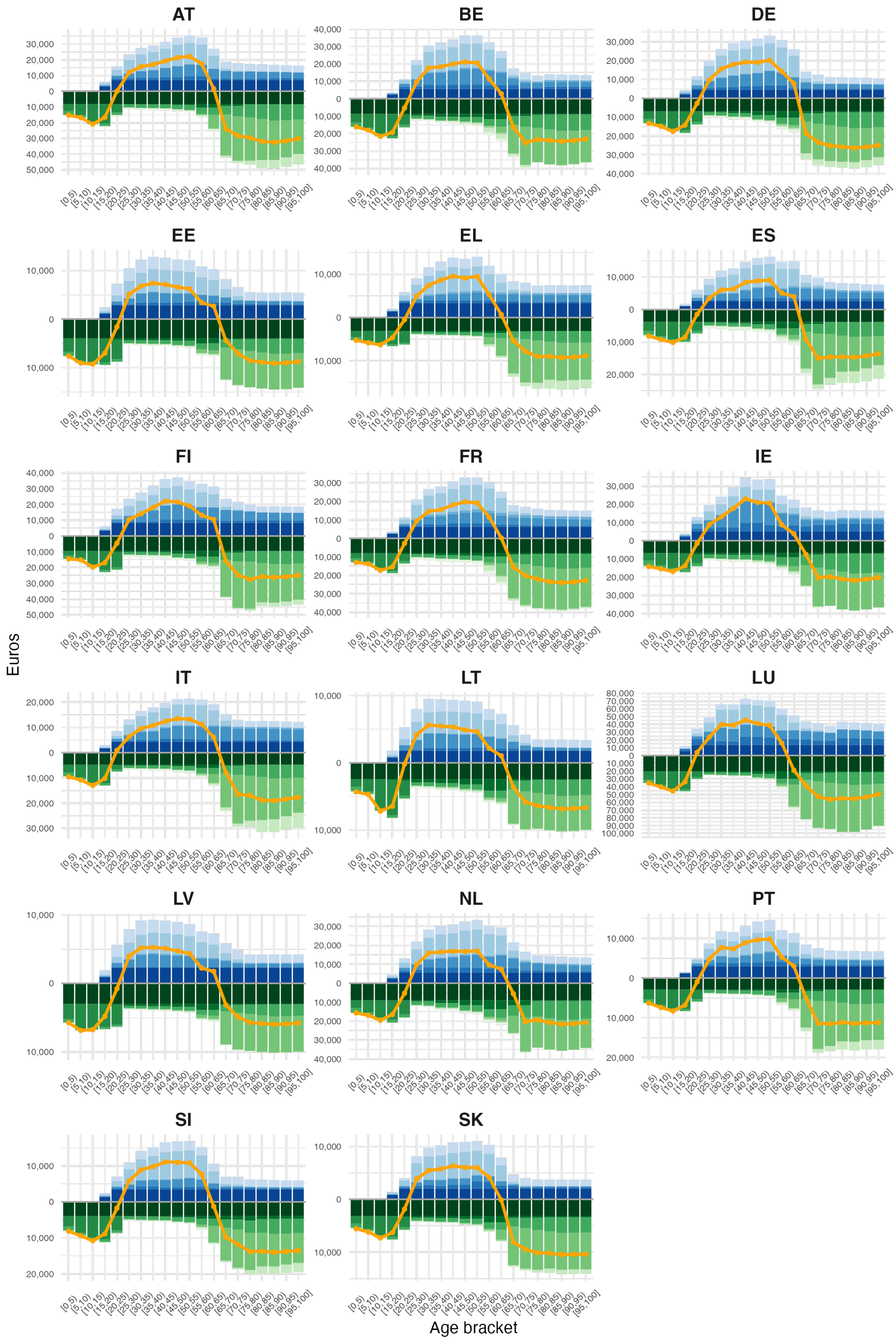


Figure 29: Mean age profile of revenues and expenditures per capita, by education level

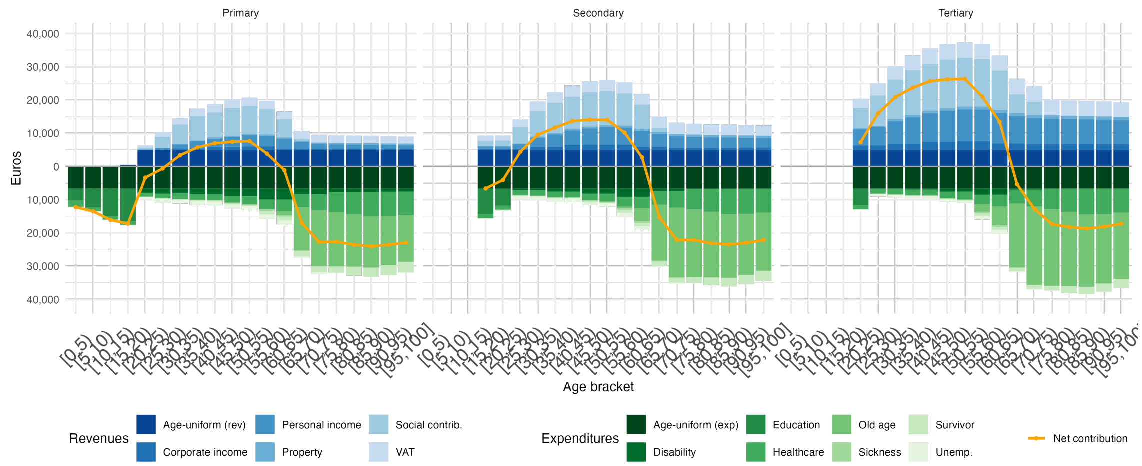


Figure 30: Mean age profile of revenues and expenditures per capita, by country of birth

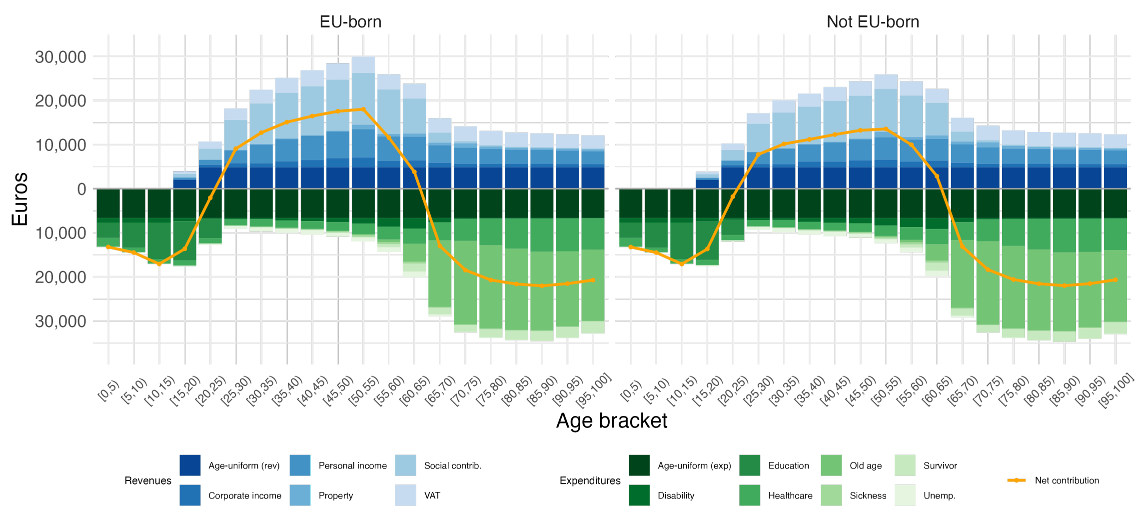


Figure 31: Counterfactual Primary Balance Implied by the Population Projections Decomposed by Gender and Education Level