Cross-Country Differences in the Contribution of Future Migration to Old-Age Financing - Appendices for on-line publication only

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A Appendix: country sample details

This appendix provides details on the choice of the countries in the representative sample and key characteristics of these countries.

The selection of representative countries is made along three criteria. The long-run financing contribution of immigration depends on demographic factors, such as the speed of population aging and the volume of immigration, and institutional factors.

As first selection criterion, we consider the strength of the population aging challenge, choosing countries which are exposed to fast population aging and countries which are not. At one extreme, the old-age dependency ratio in the slow-aging Sweden is projected to increase from 28% to 46% (a 64% increase) between 2010 and 2060. At the other extreme is the fast-aging Slovakia, where the ratio should increase from 17% to 62% (a 264% increase). Figure 1 displays the variation in the old-age dependency ratio in the European Union and shows that 7 countries are exposed to fast population aging[1], which we arbitrarily define as countries where the dependency ratio increases by more than 150%.

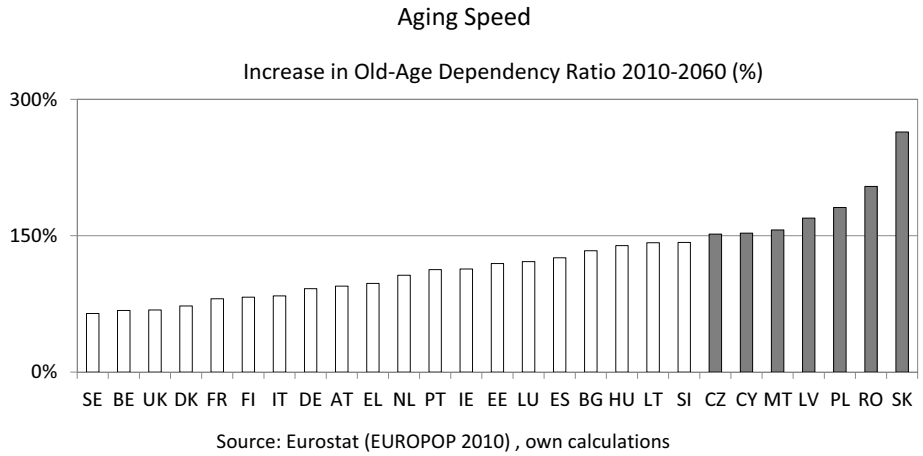

Figure 1: Population aging speed projections, European Union

[1]Countries exposed to fast aging appear with a gray bar in figure 1.

As second criterion, we consider the projected volume of migration, choosing countries which are exposed to large immigration flows and countries which are not. Figure 2 shows differences across the European Union. On the one hand, average yearly immigration flows are projected to be negative in six countries up to 2060. On the other hand, six countries are exposed to large immigration flows[2], which we arbitrarily define as yearly flows averaging more than 0.5% of the population.

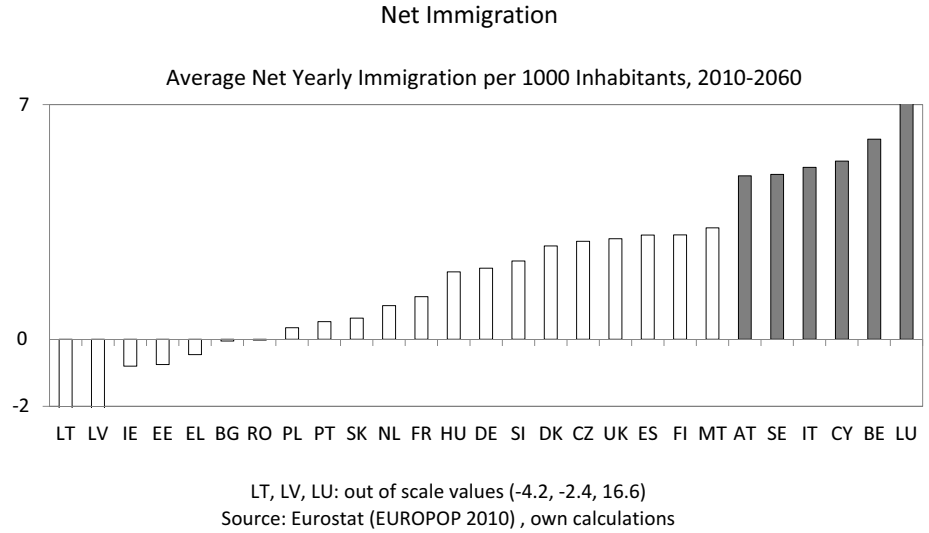

Figure 2: Average yearly net immigration projections, European Union

As third criterion, we consider the type of pension system, Beveridgean or Bismarckian. The increase in aggregate pension expenditures is indeed the main driver for the rise in old-age social security expenditures in the coming decades in many countries. Since Beveridgean pension systems usually focus on minimum income and Bismarckian systems usually have a strong earnings-related component, their financing needs differ much.

		Future Net Migration Flows: Large		Future Net Migration Flows: Not large	
Aging Speed: Fast		Beveridgean:	-	Beveridgean:	-
		Bismarckian:	(Cyprus)	Bismarckian:	Poland
Aging Speed: Not fast		Beveridgean:	-	Beveridgean:	United Kingdom
		Bismarckian:	Austria	Bismarckian:	Germany

Table 1: Selection of representative European Union countries

[2]Countries exposed to large future immigration flows appear with a gray bar in figure 2.

Table 1 provides the first outcome of the selection process. In a number of cases, several choices are possible and we perform an arbitrary choice. Two further comments are in order. First, only two countries have a Beveridgean pension system, Ireland and the United Kingdom, and none are exposed to fast aging and large immigration flows, so there is only one country with a Beveridgean system in the selection. Second, Cyprus is the only country exposed to large future immigration flows and fast aging. Because calibration of our model relies on the OECD Tax-Benefit model and other OECD sources, Cyprus is not an OECD country and there is only one country in the category of large future immigration flows and fast aging, we ignore this category. The resulting final selection is Austria, Germany, Poland and the United Kingdom[3].

To which extent immigration supports the long-term financing of social security depends on the characteristics and the integration of immigrants in the labor market.

The likelihood of a positive impact of immigration on public finances of aging countries increases when immigrants are younger than the native population. Figure 3 illustrates the age differences for the country sample and shows that the age difference is large in the United Kingdom but smaller in Poland.

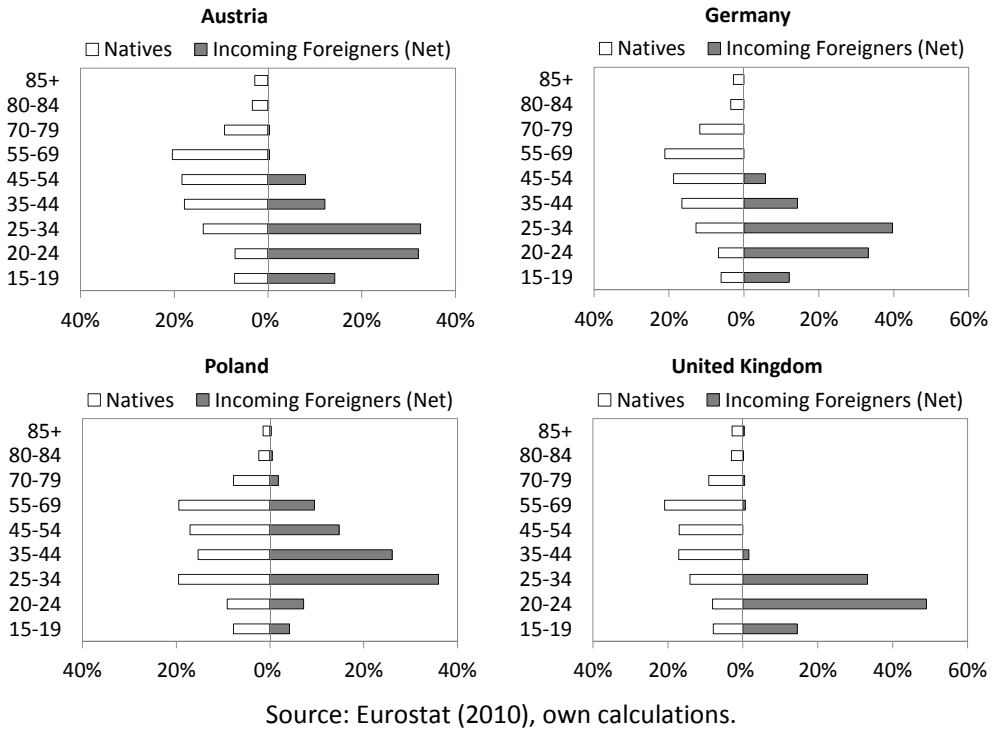

Figure 3: Age structure of natives and foreign net migrants in 2010

On average, immigrants have a lower education (skill) level, so earn less and thus contribute less to the financing of social security than native workers, but can claim only lower

[3]To verify the robustness of the selection outcome, we performed several k-means cluster analyses using various demographic and labor market dimensions, beyond the three criterias used in the selection process. The exact clustering is sensitive to removing outliers or individual characteristics. However, Austria, Poland and Germany robustly belong to distinct clusters. The United Kingdom is selected in all instances because of its Beveridgean pension system.

earnings-related benefits. Even at an equivalent education level, immigrant workers on average earn less than native workers and have lower employment (Algan, Dustmann, Glitz and Manning, 2010), with some exceptions. Figure 4 illustrates the integration of immigrants in the labor market for countries in the sample.

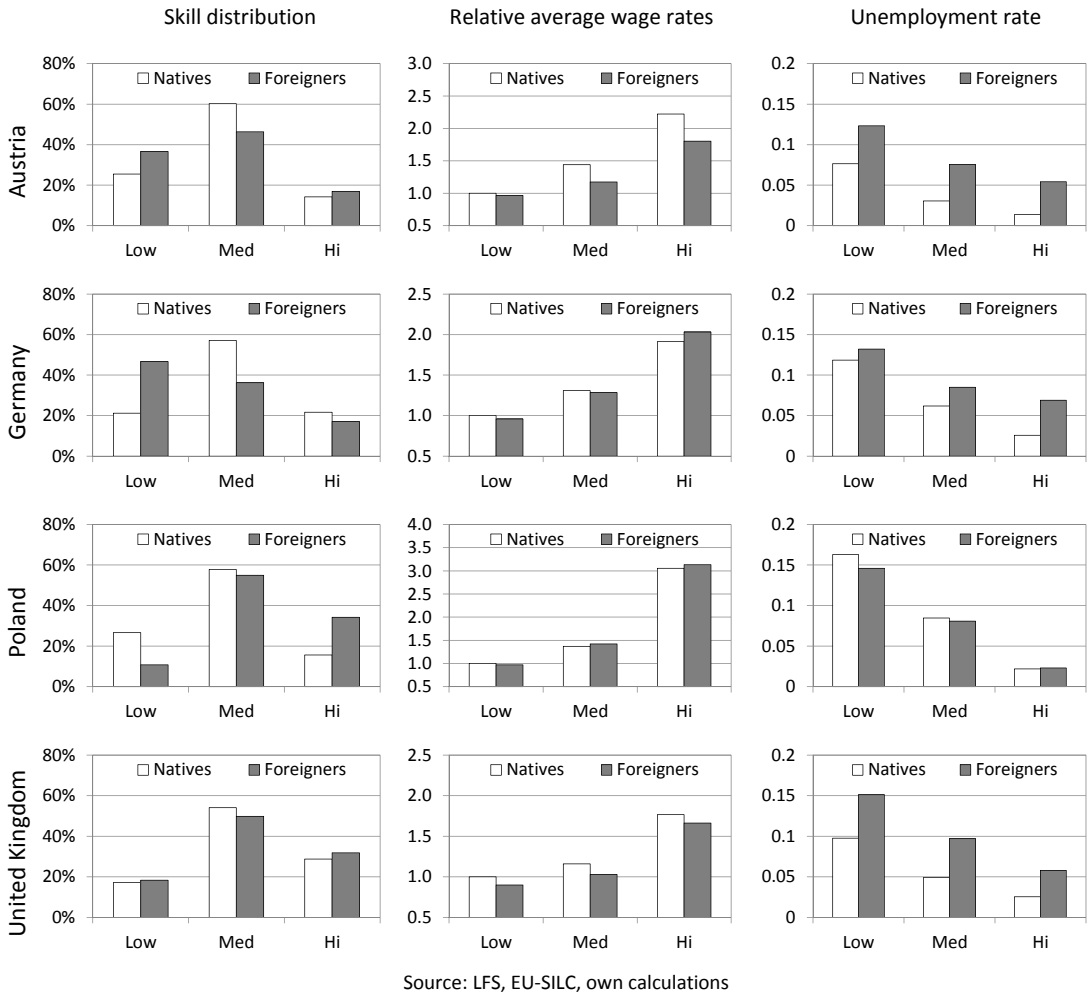

Figure 4: Labor market integration of natives and foreigners by education level

The left chart of figure 4 shows that immigrants are less educated than the native population, with the clear exception of Poland. Using data from the Labour Force Survey, the chart compares average education (skill) levels[4] of the two population groups in each country, defining native individuals as those born in Austria, respectively Germany, Poland or the United Kingdom.

The middle chart of figure 4, estimated from Mincer wage equations and EU-SILC data, shows differences in hourly wages between natives and foreigners: while there are hardly any differences in Germany and Poland, foreigners in Austria and the United Kingdom suffer from a penalty in wage rates. Foreign workers face a notable higher probability of unemployment in three of the four countries, as can be seen in the right chart of figure 4. The same data

[4]Specifically and using the 1997 version of the ISCED classification, low skill corresponds to education below high school (ISCED levels 0-2), medium skill to high school or any upper secondary education (ISCED levels 3-4) and high skill to university education (ISCED levels 5-6).

also shows differences in labor market participation and working hours between foreigners and natives. All these differences are reflected in the model calibration.

B Appendix: basic analysis

The appendix illustrates the impact of the institutional setting on the various dimensions of labor supply.

Proposition (optimality conditions): *labor market participation decisions δ_t^a for $a < a^R$, working hours decisions l_t^a, and retirement decisions δ_t^a for $a = a^R$ respectively satisfy the optimality conditions*

$$\frac{d\bar{\varphi}^a}{d\delta_t^a} = \left[(1-\tau_t^a)\, y_{par,t}^a - y_{nonpar,t}^a\right] + \gamma^a \frac{1}{R_{t+1}} M_t^a \cdot y_{par,t}^a \qquad a < a^R \tag{1}$$

$$\frac{d\bar{\varphi}^a}{dl_t^a} \cdot l_t^a = \left[(1-\tau_t^a)\, y_{par,t}^a\right] + \gamma^a \frac{1}{R_{t+1}} M_t^a \cdot y_{par,t}^a \tag{2}$$

$$\frac{d\bar{\varphi}^a}{d\delta_t^a} = \left[(1-\tau_t^a)\, y_{par,t}^a - y_{pens,t}^a\right] + \gamma^a \frac{1}{R_{t+1}} M_t^a \cdot y_{par,t}^a \qquad a = a^R \tag{3}$$

where M_t^a is a term which characterizes marginal utility variations with pension rights accumulation.

These first order conditions provide intuition for the role of institutions. Condition (1) illustrates the role of the pension system in labor market participation decisions. The marginal utility costs of increasing participation (left hand side term) has to equal the net gain of doing so in that period (first terms on the right hand side) plus the benefit which comes from building up pension rights, discounted and conditional on surviving (last term on the right hand side)[5]. As expected, larger welfare benefits $y_{nonpar,t}^a$ decrease the marginal gain from participation and thus the participation rate.

A similar interpretation holds for the condition (2) on working hours and the condition (3) for retirement, the outside options being adjusted (no income if no hours, pension payments if retirement).

The first order conditions also illustrate the impact of the *reforms* of the institutional setting on the various dimensions of labor supply. While a labor income tax increase (higher τ_t^a) impacts participation, hours and retirement decisions in a commensurate fashion, it is not the case with a pension benefit cut (lower conversion rate ν in $y_{pens,t}^a = \nu^a P_t^a + P_{0,t}^a$). In the latter case, participation and hours decisions are only impacted indirectly via pension right accumulation (terms $\gamma^a \frac{1}{R_{t+1}} M_t^a \cdot y_{par,t}^a$), while retirement decisions are also impacted directly, via the outside option (term $y_{pens,t}^a$).

C Appendix: numerical solution

We present and discuss a selection of analytical results to nourish intuition and to illustrate their contribution to numerical solutions, found with a Fair and Taylor (1983) algorithm.

[5] The term M_t^a does not add on the intuition and is ignored, for simplicity.

The selection includes aggregation results, essential for numerical solutions. For simplicity we ignore the exogenous influence of migration in the presentation, which only leads to minor modifications.

Proposition: *the following equilibrium and optimality conditions hold*[6]*:*

Individual Euler equation: *optimal consumption decisions by each individual household follow*

$$Q^a_{\alpha,t}\left(\beta R_{t+1}\Omega^a_{\alpha,t+1}\right)^{\frac{1}{1-\rho}} = G\left[\omega^a Q^a_{\alpha,t+1} + (1-\omega^a)\, Q^{a+1}_{\alpha',t+1}\Lambda^a_{\alpha,t+1}\right] \tag{4}$$

Labor supply homogeneity: *labor supply (participation and hours) decisions as well as shadow prices are independent of individual history:*

$$\begin{array}{lllll} & \delta^a_{\alpha,t} \equiv \delta^a_t & l^a_{\alpha,t} \equiv l^a_t & & \\ \bar{\lambda}^a_{\alpha,t} \equiv \bar{\lambda}^a_t & \bar{\eta}^a_{\alpha,t} \equiv \bar{\eta}^a_t & \Omega^a_{\alpha,t+1} \equiv \Omega^a_{t+1} & \Lambda^a_{\alpha,t+1} \equiv \Lambda^a_{t+1} & \end{array} \tag{5}$$

Aggregate Euler equation: *the consequence of optimal consumption decisions by households, at the aggregate level, is*

$$Q^a_t\left(\beta R_{t+1}\Omega^a_{t+1}\right)^{\frac{1}{1-\rho}} = G\left[\omega^a Q^a_{t+1} + (1-\omega^a)\, Q^{a+1}_{t+1}\Lambda^a_{t+1}\right] \tag{6}$$

where $Q^a_t \equiv \sum_\alpha N^a_{\alpha,t} Q^a_{\alpha,t}$ *is the aggregated effort-adjusted consumption for the age, skill and nationality class* (a,i,n)*.*

Intertemporal optimality condition: *for retired households* $(a > a^R)$ *making no intervivo transfers, intertemporal aggregate consumption decisions are characterized by the following:*

$$Q^a_t = C^a_t = \frac{1}{\Delta^a_t}\left(A^a_t + S^a_t\right) \tag{7}$$

with

$$\Delta^a_t = 1 + \beta^{\frac{1}{1-\rho}}\left(R_{t+1}\Omega^a_{t+1}\right)^{\frac{\rho}{1-\rho}}\gamma^a\Delta^a_{t+1} \tag{8}$$

$$S^a_t = P^a_t\nu^a_t + \frac{\gamma^a G}{R_{t+1}\Omega^a_{t+1}}\left[\omega^a S^a_{t+1} + (1-\omega^a)\, S^{a+1}_{t+1}\left(\Lambda^a_{t+1}\right)^{1-\rho}\right] = \frac{\lambda^a_t}{\eta^a_t}P^a_t \tag{9}$$

$$GP^a_t = \omega^a\gamma^a P^a_{t-1} + \gamma^{a-1}\left(1-\omega^{a-1}\right)P^{a-1}_{t-1} \tag{10}$$

We discuss each result in turn.

Labor supply homogeneity: Labor supply decisions are independent of individual his-

[6]The following notations and definitions are used in the proposition: two households in the same age group a, with the same skill level i and nationality n can differ by their life-cycle history α, a biography vector holding the information about birth date and the time an individual has moved from one life-cycle stage to the other; $Q^a_{\alpha,t}$ denotes effort-adjusted consumption for a household with biography α, and similarly for other variables; $\lambda^a_t \equiv \partial V^a_{t+1}/\partial P^a_t$ and $\eta^a_t \equiv \partial V^a_t/\partial A^a_t$ are the shadow price for a marginal increase of pension rights and assets; $\bar{\lambda}^a_{\alpha,t+1} \equiv \omega^a \partial V^a_{\alpha,t+1}/\partial P^a_{\alpha,t+1} + (1-\omega^a)\,\partial V^{a+1}_{\alpha,t+1}/\partial P^{a+1}_{\alpha,t+1}$ and $\bar{\eta}^a_{\alpha,t+1} \equiv \omega^a \partial V^a_{\alpha,t+1}/\partial A^a_{\alpha,t+1} + (1-\omega^a)\,\partial V^{a+1}_{\alpha,t+1}/\partial A^{a+1}_{\alpha,t+1}$ are the same shadow prices, but taking into account expected transitions to the next life-cycle stage; $\Omega^a_{\alpha,t+1} \equiv \omega^a + (1-\omega^a)\left(\Lambda^a_{\alpha,t+1}\right)^{1-\rho}$ and $\Lambda^a_{\alpha,t+1} \equiv (V^{a+1}_{\alpha',t+1}/Q^{a+1}_{\alpha',t+1})/(V^a_{\alpha,t+1}/Q^a_{\alpha,t+1})$ are related to the marginal rate of substitution across age groups.

tories and identical for households in the same stage, skill and nationality class. This is an important result for numerical solutions.

Aggregate Euler equation: Unlike labor supply, consumption decisions differ for every individual, as they depend on their individual histories α. Individuals indeed go through the life-cycle stages at different speed so two individuals in the same stage, skill and nationality class may have different physical age, financial assets and pension rights. Their wealth being different, they take different consumption decisions. Through aggregation, one however obtains the aggregate Euler equation (6), which is identical to the individual Euler equation (4) except that it holds at the aggregate consumption level (within each stage, skill and nationality class). Similar aggregation results hold for all individual-level optimality conditions, sometimes with adjustments, and allow to get rid of the α's. Together with labor supply homogeneity, it is an important result for numerical solutions. Indeed, to find the impact of policy reforms or demographic shocks on the economy and public finances, it is not necessary to solve the model for all possible histories α, but only for representative households in each stage, skill and nationality class ($9 \times 3 \times 2$ groups).

Intertemporal optimality condition: This result is key for using the Fair and Taylor (1983) algorithm. Similar results hold for households in different age groups and when inter-vivo transfers are made, with a more complex algebra. In the algorithm, the equilibrium at period t is derived from the equilibrium at period $t-1$, starting from the initial steady-state and given time-consistent guesses for forward looking variables in $t+1$ which are numerically found through iteration. Stock variables, such as capital and pension rights, are inherited from the previous period equilibrium and decisions. The challenge for the application of the algorithm is capturing the intertemporal optimality conditions, such as the Euler equation (6) for consumption, and equations (7-10) in recursive form. The key result is the innocuous looking relation $S_t^a = (\lambda_t^a/\eta_t^a)\, P_t^a$ in (9), which translates the accumulated stock of pension rights (P_t) into a wealth value (S_t^a), defined as the discounted sum of future pension payments. Relationship (7) then applies a marginal propensity to consume factor ($1/\Delta_t^a$) to total household wealth, the sum of actual financial wealth A_t^a and expected future pension wealth S_t^a, to define consumption decisions C_t^a.

D Appendix: calibration details

Compared to existing overlapping-generations models, there are three essential differences in the model we use. First, there are many labor supply margins. Second, institutions are modeled in details. Third, there is a labor market with different prospects for natives and foreigners. Our presentation of the calibration focuses on these three differences and population aging challenges. Parameters related to other dimensions of the model are set in a standard fashion. We illustrate with the case of Germany. The same approach is used for other countries.

Labor supply: Participation, retirement, job search effort and work hours are the four labor supply decisions made by households. The convex increasing disutility cost functions $\varphi_\delta^a(\cdot)$ and $\varphi_l^a(\cdot)$ define participation and hours decisions. Retirement decisions correspond to participation decisions at $a = a^R$. Similarly, we use a convex increasing disutility

cost function $\varphi_s^a(\cdot)$ to define search effort s_t^a. Effort-adjusted consumption, which captures the consumption-labor effort trade offs, is extended to $Q_t^a = C_t^a - \varphi_\delta^a(\delta_t^a) - \delta_t^a u_t^a \varphi_s^a(s_t^a) - \delta_t^a(1-u_t^a)\varphi_l^a(l_t^a)$, where u_t^a is the probability of unemployment.

We use convex increasing functions of the form

$$\varphi_\delta(\delta) = \delta_0 \exp\left(\frac{\delta}{v_\delta}\right) \qquad \varphi_s(s) = s_0 \frac{s^{1+1/v_s}}{1+1/v_s} \qquad \varphi_l(l) = l_0 \frac{l^{1+1/v_l}}{1+1/v_l}$$

where δ_0, s_0 and l_0 are scaling parameters so that our initial steady-state values match those observed in the data and v_δ, v_s and v_l are elasticity parameters defined by empirical estimates from the literature. Values and differences in elasticities along the intensive and the extensive margins, summarized in table 2, are consistent with the literature discussion from Immervoll, Kleven, Kreiner and Saez (2007).

Elasticity	Low	Medium	High	Interpretation
Participation	0.21	0.19	0.09	(pp) increase in participation rate for 1% increase in labor income
Hours worked	0.10	0.09	0.08	% increase in hours for 1% increase in wage rate

Table 2: Labor supply elasticities by skill level

Institutions: Institutional parameters are set to replicate average payments or total stocks, taken from OECD publications and the MISSOC database (European Commission, 2009). These include in particular parameters for the pension system and unemployment insurance. Data analysis allows to separate values by age and skill class, relying on the EU-Labour Force Survey (LFS) and EU-SILC databases.

We use OECD's Tax-Benefit model and EU-SILC data to compute average personal income tax rates and social security payments by age and skill class, capturing institutional details such as progressive income taxes and maximum thresholds of social security contributions.

To deal with financing of public pensions as population is aging, most European countries have made reforms, with immediate or future implementation. Analysis from the Ageing Working Group (2012) take these reforms into account and adjust institutional parameters of social security between 2010 and 2060. We borrow these parameter adjustments: variations in pension replacement ratios and statutory retirement age follow the Ageing Working Group (2012)[7,8,9]. Note that these adjustments take pension sustainability mechanisms

[7]The Ageing Working Group (2012) forecasts no variations in social security contribution rates.

[8]The Ageing Working Group (2012) also makes assumptions on variations in labor market participation. We ignore these variations for two reasons. First, participation is endogenous in our model. Second, the Ageing Working Group (2012) assumes increasing participation for female and decreasing participation for males, both effects essentially canceling out.

[9]Values for UK pension replacement ratios in the Ageing Working Group (2012) are not exploitable. Instead, we use variations in pension replacement ratios consistent with UK's Office for Budget Responsibility (2015).

	Wage profiles						Unemployment shock probability		
	Natives			Foreigners			Foreigners / Natives		
	Low	Med	Hi	Low	Med	Hi	Low	Med	Hi
15 to 19 years	1.00			0.96			1.00		
20 to 24 years	1.16	1.31		1.11	1.28		1.00	1.05	
25 to 39 years	1.42	1.69	2.04	1.36	1.66	2.17	0.97	1.21	1.28
40 to 54 years	1.60	2.06	2.69	1.53	2.03	2.86	1.08	1.28	2.03
55 to 69 years	1.49	2.05	2.85	1.42	2.01	3.03	1.44	1.35	2.18

Normalized 2010 wage profiles and relative probability of unemployment shock by age and skill class. Empty-cells reflect education.
Source: EU-SILC, own model calibration output

Table 3: Model calibration outcome, labor market for natives and foreigners, Germany

into account, as in Poland and Germany. Aggregate pension expenditures, an outcome of the model, are then compared to projections from the Ageing Working Group (2012) to evaluate the quality of our calibration (see below).

Labor market and immigration: As documented in section 2 of the main paper, labor market prospects for foreigners and natives are different, even at the same education level. Parameters representing exogenous wage and unemployment differences need to be computed. Wage data from the EU-SILC data and Mincer wage regressions[10] allow to calibrate age, skill and nationality profiles, as displayed in the left part of table 3.

In the complete model, search frictions and idiosyncratic shocks are the cause of unemployment, following the static search unemployment setting of Boone and Bovenberg (2002). To a large extent, unemployment shock differences between natives and foreigners represent pure discrimination, unrelated to household search decisions. The right part of table 3 displays the unemployment shock probabilities which are consistent in a stationary steady-state with unemployment average data from the EU-SILC and the static search model. The same data also shows differences in labor market participation and working hours between foreigners and natives, which are reflected in the model calibration in a similar fashion.

The speed at which foreigners obtain the German citizenship is defined by an exogenous parameter. We arbitrarily set this parameter such that it takes on average two generations to become indistinguishable from a native on the labor market (economic citizenship). Sensitivity analysis (unreported) show that outcomes are not very sensitive to this parameter.

Children's education is influenced by parents and the education system. We assume that changes in the skill distribution are more pronounced for foreigners. We therefore use EU-SILC data to compute a skill inheritance matrix for children born from foreign parents, given in table 4, to capture the dynamics of skill transition over generations of immigrants. For the

[10]Mincer regression independent variables include origin, experience and experience squared, the skill level and gender. Industry and firm-related variables can also influence wages but are ignored in the regression, as they are not included in the model.

		Offspring		
		Low skill	Med skill	Hi skill
Parents	Low skill	0.722	0.170	0.108
	Med skill	0.298	0.422	0.280
	Hi skill	0.134	0.277	0.589

Source: EU-SILC (2011) ad-hoc module
(intergenerational transmission of disadvantages)

Table 4: Skill inheritance probabilities, Foreigners

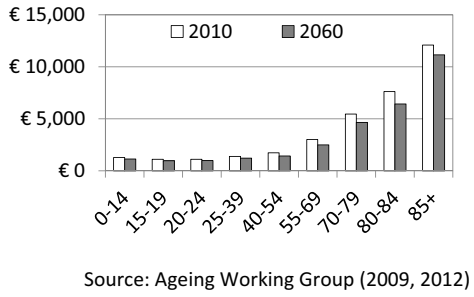

Figure 5: Yearly public health expenditures by age group, 2010 and projection 2060, Germany

native population, education decisions are endogenous and react to spillover effects on wages due to immigration changes[11].

Population aging: We use the Europop2010 population projections from Eurostat (2011) to calibrate the demographic components of the model. Net migration, total fertility and mortality rates projections are the main inputs. Because long-term variations in birth rates remain difficult to forecast (Lutz, 2007), we assume that the age distribution of fertility remains the same as in 2010. For lack of predictions, we also assume that the age distribution of future migration flows is the same as in 2010. We set the age-dependent mortality rates such that the size of the total population and the size of each age group in the model is close to the Statistical Office projections.

As per capita public health expenditures are concentrated at the top of the age distribution, population aging increases aggregate health expenditures. Medical technology and other factors also play a role. Which factor dominates is however debated (for a current view, see Breyer, Costa-Font and Felder, 2010). We rely on the compromise from the Ageing Working Group (2012) reference scenario, leading to mild improvements. The resulting health and long-term care expenditures profiles variations are displayed in figure 5.

Other dimensions: Other dimensions of the model are standard. We use production specification and estimates from Jaag (2009). Education and human capital accumulation parameters are derived from Heckman, Locher and Taber (1998) and Steiner and Wrohlich (2012). Preferences are defined by the intertemporal elasticity of substitution, using a middle

[11]There is also a positive correlation between skills of parents and their children for native Germans. However, the skill distribution of the natives is closer to a steady state.

ground value from literature estimates, as well as time discounting and bequest motives parameters, which we calibrate to replicate current age consumption profiles computed from Eurostat (2010). Labor market parameters either rely on literature estimates (matching and bargaining) or come from Mincer wage regressions on EU-SILC microdata (age and skill productivity profiles).

Calibration outcomes: Table 5 provides outcomes of the calibration. Outcomes are in line with literature standards. Aggregate social security expenditures variations are higher but comparable to the projections of the Ageing Working Group (2012) given differences in methodologies, the Ageing Working Group (2012) considering expenditures alone and neglecting impacts on factor prices (for a longer discussion, see Jimeno, Rojas and Puente, 2008).

	Austria		Germany		Poland		United Kingdom	
	2010	2060	2010	2060	2010	2060	2010	2060
	ISS	Mig	ISS	Mig	ISS	Mig	ISS	Mig
Demographics								
Population (15+)	100.00	108.08	100.00	84.17	100.00	87.44	100.00	128.08
Share of foreigners	10.39	29.58	9.00	17.03	0.13	2.81	7.38	25.32
Dependency ratio	26.27	50.24	31.35	59.67	22.21	58.81	26.51	40.48
Labor market								
Effective retirement age	59.76	61.22	61.43	62.65	60.14	61.28	63.60	64.99
Gross wages (% ISS)	-	-3.71	-	-0.84	-	8.41	-	-3.96
Macroeconomics								
GDP/capita (% ISS)	-	-19.67	-	-17.97	-	-12.93	-	-13.48
Public finance								
Pension benefits ratio (p.p. ISS)	-	-12.53	-	-5.41	-	-28.97	-	-2.58
Health and LTC expenditure (% GDP)	8.22	12.02	9.40	13.83	4.99	7.55	8.92	10.93
Pension expenditure (% GDP)	14.22	18.64	11.93	17.58	10.93	9.11	8.19	10.45

See main article for comments.

Table 5: Calibration and related simulation outcomes

E Appendix: method assessment

We perform two sensitivity analysis experiments to evaluate the impact of our methodological choices and the robustness of the results. To save space we focus on one country and one instrument financing the end of immigration, respectively Germany and labor income taxes.

Endogenous participation: The literature contains several quantitative evaluations of the impact of immigration on public finances with an aging population without endogenous extensive labor supply margin. By contrast, participation decisions are endogenous in our analysis. Below we evaluate the importance of this margin.

We use a partial model with exogenous and constant participation and compare outcomes with the full model outcomes used in the main article. Results are contained in the left part of table 6. Outcomes with the full model (column *Baseline*) are repeated from the main article for convenience. In the partial model (column *Const Part*), the participation rate within each age, skill and nationality class is kept constant for workers before retirement age.

	2010 ISS	2060 No Mig Tax Baseline	2060 No Mig Tax Const Part	2060 No Mig Tax Full Sust
Demographics				
Population (15+)	100.00	75.23	75.23	75.23
Share of foreigners	9.00	8.85	8.85	8.85
Dependency ratio	31.35	66.43	66.43	66.43
Labor market				
Effective retirement age	61.43	62.56	62.47	62.51
Unemployment rate	6.79	7.69	7.52	8.31
Effective employment (yearly h /capita)	721	556	568	537
Gross wages (% ISS)	-	2.12	1.84	2.98
Macroeconomics				
GDP/capita (% ISS)	-	-21.38	-19.76	-23.96
Assets/capita (% ISS)	-	31.45	30.54	29.66
Consumption/capita (% ISS)	-	-18.24	-16.64	-21.11
Public finance				
Labor income taxes (p.p. ISS)	-	7.31	5.78	8.33
Pension benefit ratio (p.p. ISS)	-	-5.08	-5.05	-5.18
Lump-sum transfer/capita	-	-12.15	-12.15	-11.07

Baseline: baseline model (with endogenous participation decisions, simplified sustainability factor implementation based on Ageing Working Group, 2012), taken from the main article;
Const Part: participation rate of pre-retirement age workers is kept constant at the 2010 value.
Full Sust: full sustainability factor implementation. See main article for additional comments.

Table 6: Simulation results, sensitivity analysis, Germany

The main result shows that the value of future immigration flows is underestimated when one neglects endogenous participation responses: holding participation constant within each age, skill and nationality class, the loss of revenue attached to the end of immigration in Germany could be covered by an increase in labor income taxes of only 5.8 percentage points,

instead of 7.3 percentage points in a model with endogenous participation. This finding motivates our usage of a macroeconomic model with a fine labor market representation, making a difference between intensive and extensive margins.

The source of the bias are the disincentive effects of taxation. These effects operate along all dimensions of labor supply, intensive and extensive margins. When labor market participation decisions are removed from the model, some disincentive effects of the labor income tax increase are not captured. Effective employment drops less (568 yearly hours per capita in the *Const Part* case instead of 556 in the *Baseline* case), leading to counterfactually high government tax revenues. A smaller increase in the tax rate is sufficient to cover the loss of revenue due to the end of immigration.

German sustainability factor: Poland implemented a sustainability factor which depends on demographic evolutions alone, pension benefits being adjusted to the remaining life expectancy to secure pension financing. In Germany, the sustainability factor adjusts both pension benefits and social security contributions and also depends on economic conditions in general equilibrium[12]. The analysis of the Ageing Working Group (2012), which is not performed in a general equilibrium framework, takes pension benefits variations into account but keeps social security contribution rates unchanged. With our calibration relying on Ageing Working Group (2012), the baseline case estimates are thus accurate for Poland but may be biased for Germany[13].

We repeat the baseline analysis for Germany with a more complete implementation of the sustainability factor, adding social security contribution rate projections as in Moog, Mueller and Raffelhueschen (2009). Results are contained in the right part of table 6, to be compared to the baseline case. Outcomes are similar: increasing labor income taxes by 7.3 percentage points is sufficient to finance the end of immigration in Germany in the baseline case (in column *Baseline*); 8.3 percentage points are needed in the complete implementation case (column *Full Sust*).

The baseline case, which implements a simplified version of the sustainability factor in Germany, thus underestimates the public finance impact of immigration. The conservative estimates it provides however allow for an easier comparison with other countries. Accounting explains the difference between the two cases: social security contributions can be deducted from the taxable income, leading to a smaller tax base and larger need to increase the tax rate in the complete implementation case.

[12]Part of the literature use the words "sustainability factor" for one component, but not all of the German automatic adjustment mechanism (known as *Rentenanpassungsformel* in Germany). For simplicity, we use "sustainability factor" for Germany, as for other countries, to refer to the complete adjustment mechanism. See Moog, Mueller and Raffelhueschen (2009) for details on the German adjustment mechanism.

[13]Because sustainability mechanisms operate in a symmetric fashion for natives and immigrants, our calibration approach is accurate for the first type of mechanisms (Poland) both in our baseline case (with immigration) and in our counterfactual scenarios (with an end to immigration).

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