Impacts of Immigration on Aging Welfare-State

An Applied General Equilibrium Model for France

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Abstract

Immigration is often seen as an instrument of adaptation for aging countries. In this paper, we evaluate, using a dynamic general equilibrium model, the contribution of migration policy in reducing the tax burden associated with the aging population in France. Four alternative scenarios, compared to a baseline scenario based on official projections, are simulated with the aim to quantify the immigration effects on the French social protection finances. We show that the age and, to a lesser extent, the skill structure of immigrants are the key feature that mainly determine the effects on social protection finances. Overall, these effects are all the more positive in the short-medium term that the migration policy is selective (in favor of more skilled workers). In the long term, beneficial effects of a selective policy may disappear. But whatever the degree of selectivity of migration policy, the financial gains from more consequent migration flows are relatively moderated in comparison of demographic changes implied.

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Keywords: Migration, AGEM, Overlapping generations, Aging, Public finance, Social protection.

Highligths:

- We show that immigration, as projected in official forecasts, reduces the tax burden of an aging population.
- These benefits are mainly linked to the younger age distribution of net flows compared to the total French population.
- However, the financial gains are relatively moderate in comparison to the demographic evolution implied by aging.
- A more selective policy, in favor of skilled workers, can amplify these gains in the short to medium term but this improvement disappear in the long term.

1 Introduction

France, like many European countries, is undergoing a process of population aging. it is induced by the combined effect of lower birth rates and continually longer life expectancy. This new demographic change is temporary amplified by the aftershock of generations of *baby boomers* and will weigh heavily on France's public finances. On the basis of current policies, public spending directly related to age could increase by about 3.1 percentage points of GDP according to the European Commission (2012). Unfortunately, the slow growth of French working age population would not be able to absorb this increase of social expenditure. The need to mitigate the announced negative effects of population decline on economic activity has led the debate on a policy of "replacement migration". Acting on the flows of immigrants, rather than on fertility rates, has the double advantage of having a rapid effect and of being more manageable by public authorities. Therefore, this debate on replacement migrations arrives at the same time as that of selective migrant policies. Two arguments are generally given to promote such a shift in the immigration policy. A quota system ensures a better match between the supply of foreign labor and the specific needs of the host economy. The second argument is relative to the net contribution of immigrants to public finances. Most studies[1] indicate a relatively neutral effect of immigration on public finances. The magnitude of this effect, however, is dependent on the level of skills and on the age distribution of the immigrants.

Questions about the impact of immigration on social protection raises interest in some of the main characteristics of the immigrant population. According to the 2009 census, there were 5.4 million immigrants in France, equivalent to 8.5% of its population and more than 6 million descendants of immigrants (Breem (2013)). The age structure of immigrants in France is clearly different from that of natives. Young people are under-represented since by definition immigrants are not born in France. Conversely, we observe that immigrants are aggregated in the active age groups: 55% of them are aged 25 to 55 years against 40% for the french population as a whole. This particular structure of the immigrant population living in France is very dependent on the size and especially the age structure of migration flows. In 2009, the average age at migration was 32 years and 70% of new entrants were aged less than 30 years. Finally, migrants in France are generally less skilled than natives, even if the educational level of immigrants is on the increase. In 2009, the low skilled immigrants (diploma below the bachelor degree) accounted for 53% of 35 years against 39% of natives of the same age while at the same time the most highly skilled (diploma above two years after a bachelor level) accounted for 30% among immigrants against 41% for natives.

There is significant literature on the impact of immigration on the labor market, on public finances, on economic growth, and on inequalities[2]. However, the majority of these studies adopt the framework of partial equilibrium and are subject to two major drawbacks. First, the partial equilibrium framework, by definition, poorly captures the interdependencies between different markets or the response of natives to an immigration shock. Indeed, the geographic mobility of natives, the changes in their labor supply, and their educational choice must be integrated in the framework in order to properly capture the impact of

[1] See Auerbach & Oreopoulos (2000) on the United States; Bonin, Raffelhüschen & Walliser (2000) on Germany; Collado, Iturbe-Ormaetxe & Valera (2003) on Spain; and Chojnicki (2006), (2013), and Monso (2008) on France.

[2] For a survey of literature on the economic effects of immigration, see Borjas (1999), (2013) and Brücker, Epstein, Mc Cormick, Saint-Paul, Venturini & Zimmerman (2002).

immigration. Second, the absence of a unified framework makes the dissociation between minor and major effects from immigration extremely complicated. Although the largest strand of literature focuses on the labor market impact of immigration, this effect is possibly less important in size than fiscal responses or growth enhancing impacts.

Our model attempts to overcome these shortcomings. Most of the ingredients of the immigration literature are included in a harmonized framework where firms, the government, and heterogeneous households interact:

- The entry of new workers affects productivity of production factors (and hence wages and return to saving). Redistribution occurs from workers to suppliers of physical capital.
- Another redistribution between workers is also occurring. Immigrants are generally less skilled than natives; their arrival causes downward pressure on the wages of unskilled workers and increases pressure for training.
- The budgetary impact of immigration depends on the type of migrant considered, the age distribution of immigration flows, and also their skill level.
- Through its impact on wages, interest rates, and taxation, immigration induces indirect effects on natives' choices of labor supply, human capital investment, and saving.

All these induced effects involve an infinite sequence of perturbations on the demand and supply of factors, which can reinforce or attenuate the direct effect. In appendix C, we evaluate the general equilibrium effects compared to direct effect of immigration by simulating alternative partial equilibrium models in which wages and interest rate responses are neutralized.

Our benchmark scenario is built from the INSEE's demographic projections of 2010. Four alternative immigration scenario were performed with the aim to better quantify the effects of immigration on the finances of social welfare in France. The first alternative scenario assumes that net immigration flows are zero from 2010 and for all subsequent years ("without immig." scenario). The gap between this scenario and the baseline measures the economic situation with and without immigration planned for the period. The three other alternative scenarios take the opposite view, making a more ambitious effort to measure the effects of immigration as a function of its skill structure. We study the effects of an additional inflow that may be considered as "realistic" (corresponding to flows that have characterized the second great wave of immigration in France in the 20th century between 1954 and 1961). These three scenarios only differ in the skill composition of new migrants.

We show that immigration, as projected in official forecasts, reduces the tax burden of an aging population. In its absence ("without immig." scenario), the financing need of social protection in 2060 increases from 1.9% to approximately 2.9% of GDP. These benefits are mainly linked to the younger age distribution of net flows compared to the total French population and affect, principally and not surprisingly, the two pillars of welfare system most sensitive to demographic changes: pensions and health care. For similar reasons, a more ambitious immigration policy would contribute to reducing the tax burden of an aging population. However, the financial gains are relatively moderate in comparison to the demographic evolution it implies. A more selective policy (in favor of skilled workers) can amplify these gains in the short to medium term but this improvement is only temporary. In the longer term, demographic changes related to a more selective immigration (especially

from lower fertility rates and longer life expectancy from skilled migrants) outweigh its benefits relative to a non-selective policy.

The rest of the article is structured as follows. The main characteristics and properties of the model are outlined in Section 2. The calibration method and data used are described in Section 3. Section 4 presents the simulation results of the baseline. Section 5 assesses the impact of different migration scenarios on main macroeconomic aggregates and on social protection finances. Section 6 concludes.

2 Modeling population and the economy

To assess the impact of immigration on the public finances, it is necessary to accurately describe the demographic and economic environment in which migrants interact with natives.[3] For this, we develop an applied general equilibrium model with overlapping generations (AGEM-OLG) of heterogeneous agents in line with the work of Auerbach & Kotlikoff (1987).[4] This requires modeling and calibrating demography, technology, individual behaviors and state intervention. Our model distinguishes three agents: households, firms and the governement. In- and out-migration are the only sources of exchanges with the rest of the world. As in Storesletten (2000), we assume that trade and financial flows are too small to make a difference. This means that we rule out any interdependencies between movements of goods, capital and persons. Here is a description of the main features of this model. The period of the model is set to ten years, so it is a model of medium- and long-term analysis. A more detailed representation of the latter is provided in appendix A.

Demography. The demographic block provides an accurate representation of the structure of the French population. It relies on a complex demographic block with 48 types of individual per period, distinguished by age, education level and national origin. Immigrants are defined as individuals who were foreign-born and who do not have French citizenship at birth. In the spirit of Storesletten (2000), immigrants' children are considered as natives. Population is also disaggregated by educational attainment and we distinguish low-skill, medium-skill and high-skill individuals. Fertility differs across skill and origin groups whereas mortality rates are only allowed to vary between skill groups. Calibrating this demographic block requires historical and prospective data on educational choices, fertility, mortality, in-migration and out-migration (see section 3).

Technology. The production sector plays a crucial role since it defines the way immigrants compete with native workers on the labor market.[5] Instead of defining several labor markets (for low, medium and high-skill workers, for young and old workers, etc.), we assume that workers belonging to different age, skill and ethnic groups are not perfectly substitute, because they have a different educational attainment/experience mix. Building on Ben-Porath (1967), we combine these components according to a constant elasticity of substitution technological function. These components are determined endogenously and depends on productivity changes (introduced to capture economic growth and changes in

[3]The theoretical structure of the model presented here is quite similar to the one used to study the impact of postwar immigration on the US economy (Chojnicki, Docquier & Ragot (2009)).

[4]Two studies, Storesletten (2000) and Fehr, Jokisch & Kotlikoff (2004), adopt a relatively similar analytical framework.

[5]A sensitivity analysis on the main parameter of this production function is presented in appendix B.

the skill premium). However, the stocks of education and experience are homogeneous. The interest of this approach is that the number of competing factor is independent of the number of groups considered. It slightly differs from the approach of Card & Lemieux (2001) or Borjas (2003) that aggregates age-specific levels of human capital in a CES function; the number of nested functions depends on the numbers of age group considered. We are more in line with Heckman, Lochner & Taber (1998) who used a general equilibrium model with a sophisticated labor market. Our production function is then independent on the number of periods of life and education groups distinguished. The average experience and education level of immigrants differ from that of natives. Immigrants and native workers are thus imperfect substitutes on the labor market.

Preferences. Individuals have an uncertain life expectancy resulting from the probability of dying at the end of each period of life. They maximize an expected life-cycle utility function that only depends on consumption expenditures. In the spirit of Arrow-Debreu, we assume that every individual has the opportunity to insure himself against uncertainty at the beginning of his/her life. We assume that immigrants have the same wealth as natives of the same skill and age when they enter the country. This means that low-skilled immigrants enter the country with a low degree of wealth, while an immigrant with higher skills will bring more wealth. This methodological choice is relatively close to that of Fehr et al. (2004) but differs from Storesletten (2000), who assumed that immigrants bring no wealth. However, this choice has only a marginal role in the results, as 70% of immigrants enter France before age 30, that is, at the beginning of the period of wealth accumulation.

Educational choices. Through its effect on wages, interest rates, and tax rates, immigration induces behavioral changes among natives. Our model accounts for the effect on natives' education decisions. Individuals in two distinct skill groups are differentiated by the year of schooling or, equivalently, by the time invested in education in the first period of their life. Hence, each young agent selects his/her optimal level of schooling by comparing the monetary gain and the effort required for achieving a diploma. The time invested in education influences labor supply, education related human capital and the accumulation of experience.

Wages and unemployment. Following Layard, Nickel & Jackman (1991), we adopt a WS-PS approach (Wage Setting - Price Setting) to determine the levels of real wages and equilibrium unemployment at the aggregate level. In line with d'Autume & Quinet (2001), we assume that wage negotiations between firms and labor unions lead to a real wage determined by applying a mark-up. These negotiations occur independently by two unions representing the interests of unskilled workers and skilled workers, respectively (natives and immigrants are treated in a similar way for a given skill group). Claims of employees consist in applying a mark-up on the reservation wage that grows at the same pace as productivity to ensure the existence of a structural unemployment in the long-term. In addition, this mark-up is expected to decrease with the level of the average unemployment rate in the economy, thereby resulting in an erosion of effective bargaining power of unions in case of a shortage of labor demand.

Public finances. Immigration also impacts on the receiving economy through the public finance channel, i.e. through taxes and transfers. Due to their specific age and skill characteristics, the net contribution of immigrants to the government budget differs from that of natives. In our model, public transfers sum up education subsidies, pensions, health costs, unemployment benefits, housing costs, family allowances, and social assistance spendings. The government issues bonds and levies taxes on labor income, on consumer

spending, and on capital income to finance public transfers and public consumption. Social transfers are also supported by a number of specific social security contributions, including social contributions based on work income and General Social Contribution based on both wages and capital income.

3 Calibration of the baseline

Calibration implies using data for observed exogenous variables, fixing some constant parameters and choosing paths for the unobserved exogenous variables (for which time series data are not available) in order to match a series of characteristics. Calibration is not focused on reproducing the characteristics of a given steady state, where all the interesting information on population history, experience stocks and skills by age group would be lost. Instead, the equilibrium is computed as a transition from one steady state in 1900 to another in 2250. Our alternative scenarios only focus on the transition path.

3.1 Demographic data

In the baseline, the demographic block is calibrated to match the structure of the French population between 1970 and 2010 and to generate demographic forecasts compatible with the latest projections of Insee (Chardon & Blanpain (2010)). Historical data on the age, skill and origin structure is obtained from the population censuses of 1968, 1982, 1990, 1999, 2005 and 2010.

To calibrate fertility, mortality, and net emigration rates, we use the following method. Data from population censuses allow us to determine the proportion of people who are low-, medium-, and highly-skilled among young people. In the baseline, these shares are set to their observed values, and the educational endogenous process is calibrated to reproduce their historical path. The skill structure of future cohorts is stationary: it gradually catches up with the skill structure of the cohort aged 15-24 in 2010. Population projections are made by taking the assumptions of the central scenario of the latest projections from INSEE (Chardon & Blanpain (2010)). The data on fertility differentials by education level and origin are obtained from the national survey on health in 2003 (Enquête soins/santé). Death rates by age and educational level are calculated on the basis of life tables by age over the period 1900 to 2005 by Vallin & Meslé (2001) and official projections of the population by Chardon & Blanpain (2010) from 2005 to 2060. Differences in mortality by level of education are based on Monteil & Robert-Bobée (2005).

Starting from the structure by age, educational level, and origin of the population in 1970, the demographic block is used to identify the two exogenous processes for which we have no data, i.e. the net emigration rates of natives and immigrants between 1970 and 2100.

3.2 Parameters and observed exogenous processes

Parameters. A set of parameters is set a priori and their value is reported in table 1. For most of them, the retained values are commonly used in such calibrated models. The parameter values of production function, educational decision and human capital accumulation are chosen to deliver an adequate wage profile (see section 3.4). The only parameter giving rise to debate is the elasticity of substitution between raw labor, education

and experience. In the baseline, we use a value of 0.7 implying an elasticity of substitution of 3.33 ($1/(1-\rho)$). This baseline value corresponds to the elasticity of substitution between low-skill and high-skill labor in classical production functions. Since we use a different type of technology, we provide a sensitivity analysis to this parameter by setting values of 0.5 and 0.9 in the appendix.

- Insert Table 1 -

Parameters of the ability distribution must be calibrated to match the evolution of educational attainment in France. We estimate these parameters by a standard OLS regression. As shown on figure 1, this distribution provides an accurate prediction of the rise in educational attainment between 1900 and 2100. This identified process is used as exogenous in the alternative scenarios.

- Insert Figure 1 -

Observed exogenous processes. In our model, we have three proportional taxes: the endogenous equilibrium tax (on labor and capital income), the capital income tax and indirect taxes. These tax rates are calibrated so that the proportions of different income in GDP correspond to the observation. The evolution of these taxes reproduces the historical evolution of tax revenue as a percentage of GDP. We also consider a series of taxes specific to the social protection financing: social contributions (based on wages), earmarked taxes (based on wages and capital income) and public contribution. These taxes are calibrated using the social protection accounts. We also distinguish two types of government spending (net of debt charges): non-age-specific public consumption and age-specific transfers taken from Chojnicki (2013). The path of public debt is given exogenously and the equilibrium tax adjusts to balance the budget.

3.3 Unobserved exogenous processes

To identify the unobserved exogenous processes, our methodology follows two steps. Starting from the baseline (matching French demographic and economic trends), we use the model to identify several unobserved processes such as the total factor productivity, the skill-biased technical progress, the scale factor of pensions benefit, the scale factors of age-specific social transfers, and the scale factors of the rate of unemployment among unskilled and skilled workers. These exogenous processes are used to reproduce related observed endogenous processes: the GDP growth rate, the wage gap between highly-skilled and low-skilled individuals aged 45, the share of pension expenditures in the GDP, the share of other social transfers in the GDP, and the unemployment rates for unskilled and skilled workers.

Basically, this methodology involves swapping these unobserved exogenous processes for the same number of observed endogenous processes as a preliminary identification step. Then we solve the transformed model to identify the path of unobserved exogenous variables that exactly matches observation for the true endogenous. This resembles the recursive approach (backsolving) of Sims (1990) for general stochastic equilibrium models. We use a similar idea of treating exogenous processes as endogenous, not to solve the model but as a calibration mechanism in a deterministic framework. This procedure allows us to

calibrate the model dynamically and is more rigorous than performing the calibration in a hypothetical steady state as is done in most CGE models, such as that of Auerbach & Kotlikoff (1987)).

3.4 Wage and asset profiles per age

Given the backsolving approach, the baseline scenario matches fairly well the major "first-order" processes of the French economy (GDP growth rate, evolution of pensions and transfers, wage gap between high-skill and low-skill workers, unemployment rates). We have seen before that our endogenous education process gives a good approximation of human capital evolution for the post-war period. The quality of our model also depends on its ability to match individual wage and asset profiles per age. For that purpose, we compare the model's outcome with historical data (Labor Survey for the wage profile and Household Wealth Survey for the asset profile).

Firstly, the shape of the wage profile per age is fully determined by the accumulation and depreciation of experience and human capital (*cf.* figure 2(a)). Contrary to Auerbach & Kotlikoff (1987), there is no need to assume an exogenous profile. This figure comforts us in the choice of the experience and human capital accumulation function parameters. Secondly, it is usually argued that the standard life cycle model with selfish households does not provide a good description of wealth accumulation after retirement. It appears that our model matches the profile (*cf.* figure 2(b)). Hence, there is no need to suppose a pure time preference parameter on top of the mortality rate.

- Insert Figure 2 -

4 The baseline scenario

The French population at the beginning of the century is marked by the following facts:

- The total population of France in 2060 should be approximately 76.5 million, an increase of over 11 million people compared to 2010 (Table 2). This increase continues in the second half of the century, but at a slower pace, with a total population reaching 82.3 million in 2100. The specter of declining population is no longer a concern in France if these new demographic assumptions are confirmed in the future.
- This positive outlook is reflected in the evolution of the working-age population. It is expected to slightly increase reaching an estimated 42.5 million people by 2060.
- If one accepts the traditional image of the "scissors effect" (an increase in the number of elderly and a reduction of the working-age population) to characterize the demographic prospects anticipated in the early 2000s, one must note that new projections only retain increase in longevity. However, the data in Table 2 show that it is, indeed, this longer life expectancy that is the main cause of the aging population. The dependency ratio is a good indicator of this process. It should increase from 27.7% in 2010 to over 47% in 2060.
- Finally, with a positive net immigration of 100,000 people per year, the share of immigrants (all generations) in the total population is expected to grow continuously

over the first half of the century, from 8.3% in 2010 to 9% in 2040, while it is expected to decline slightly in the second half.

- Insert Table 2 -

These demographic changes are accompanied by a profound change in the education distribution of the working-age population (see Table 3). In the coming decades, maintenance of the education level of young native at current levels will drive an increase in skills of active cohorts (ages 15 to 64). The group of highly skilled natives is expected to increase from 32.4% in 2010 to approximately 43.1% in 2060, medium-skilled natives from 18.5% to 22.7%, and low-skilled natives will from 49.1% to 34.2% in 2060. This process of increasing educational standards, which is not unique to France, is also found in the immigrant population. The share of highly skilled immigrants is expected to increase from 25.1% in 2010 to 33.2% in 2060 and the share of low-skilled immigrants will shrink from 60.5% to 49% over the same period. However, the initial situation, characterized by an education distribution of immigrants far less favorable than that of natives, shows that immigration undermines the global improvement of skills of the working-age population.

- Insert Table 3 -

These significant demographic changes, particularly in the dependency ratio and the skill structure of the working age population, will have significant effects on economic activity and on the finances of social protection. As shown in Table 4, the average human capital per worker increases substantially until 2040 and then stabilizes. Assuming the skill level of youth is maintained at the current levels, the baseline scenario foresees a rise in human capital in active cohorts. It contributes to economic growth, which is nevertheless strongly influenced by exogenous technical progress. Throughout the period 2010-2060, the baseline scenario is thus characterized by an average annual rate of GDP per capita growth of 1.3% which is fully compatible with the official forecasts of Conseil d'Orientation des Retraites (2012). At the same time, the unemployment rate gradually decreases. Starting from 9.1% in 2010, it reached its long term long-run equilibrium value of 4.5% from 2030. The fall in unemployment operates for all skill levels.

- Insert Table 4 -

The effects of aging are much more apparent in regard to the finances of social welfare (see Table 5). Social welfare expenditures will increase around 4.7 points of the GDP in 2060 compared to 2000 and 1.5 point compared to 2010. This will stabilize around the value reached in 2060 over the second half of the century. Financing needs will reach 1.9% of the GDP from 2060 onward, while the budget for social protection was broadly balanced in 2000. Table 5 also describes more precisely the changes in the financing of social protection by disaggregating each of its five pillars: pensions, health care, family and housing, unemployment, and social assistance. The financing need for the social protection described above stems from the financial situation of retirement pensions and health care.

Not surprisingly, these two pillars are the most sensitive to aging populations. The other three pillars experience budget surpluses, which are, nevertheless, insufficient to offset the needs of the other funds' deficits.

As always in this kind of exercise, some caution is necessary when analyzing the results of the baseline scenario: it is not a prediction of the model in the long term but a projection dependent on assumptions retained. However, this scenario has been the subject of particular attention so as to reproduce official macroeconomic projections, those of financial variables of social protection and the latest demographic projections of Insee. Even so, the interest of the model lies rather in the results of alternative scenarios simulated, i.e. the analysis of the dynamics of the main variables of interest compared to the baseline when considering migration shocks.

- Insert Table 5 -

5 The impact of immigration on public finances

Compared to the benchmark, our alternative scenarios are based on the same parameter set and the same paths for exogenous variables except immigration flows.

5.1 The demographic consequences of four scenarios of immigration policy

As stated in the introduction, we simulate four scenarios of the immigration policy. The first one is built on the assumption of zero net flows after the year 2010 and for the entire length of the simulation. In other words, it describes the changing French demographics and economy without (net) immigration. The comparison of the obtained results with those of the baseline measures the impact of immigration as reflected in official population projections and its contribution to the evolutions of the finances of the social welfare system. The other three scenarios are developed on the basis of an ambitious immigration policy that serves as a way to reduce the tax burden of an aging population. From a quantitative point of view, this policy seeks to regain immigration patterns similar to those observed during the second great wave of immigration from 1950 to 1960, which was approximately 0.35% of the total population. The level of flows remains the same for all three scenarios, that is, approximately 225,000 people in 2010, and nearly 280,000 at the end of the century (Table 6). Only the skills distribution changes. In the first alternative scenario (*non-selective immigration policy*), flows characteristics are identical to those of immigrants from the baseline scenario. In the second alternative scenario (*neutral immigration*), the immigration policy imposes a skills distribution on immigrants identical, in each period, to those of the entire French population of the baseline scenario. The last alternative scenario (*selective immigration*) considers an extremely selective immigration policy where the skills distribution of incoming people is similar to the generation of the most skilled natives, the generation aged between 25 and 34, for all periods of the baseline scenario.

Table 6 identifies the main demographic implications of each of the scenarios considered. The scenario without immigration, has a major effect on the French population. The total population, compared to the baseline, is reduced by approximately 11% in 2060 and

over 21% by the end of the century. The effect is more pronounced for the working-age population at -13.1% and -23.2%, respectively. Immigrants in the French population aged 15 and over, not surprisingly, continue to decline. They represent only 2.9% of the population in 2060 compared with 10.3% in the baseline. Furthermore, there are no more immigrants in the French economy at the end of the century. Transitory effects on the skill distribution of immigrants are unfavorable as the suppressed inflow, relative to the baseline, has a higher level of skill than immigrants already in France. Similarly, new immigrants are relatively young and the dependency ratio deteriorates significantly from 47.5% in 2050, to 46.8% in 2100, compared to 44% and 43.7%, respectively, in the baseline.

- Insert Table 6 -

Regarding ambitious immigration policies, the significant increase in immigrant flow leads to a continuous increase in the proportion of immigrants in the population 15 years of age and older. This amounts to 12.6% in 2020 compared to 10.2% in the baseline and reaches a maximum (*selective immigration*) of 18.8% in 2060 versus 10.3% in the reference scenario. From 2040, the increase is even more important with a selective policy. This result is due to differential effects on the denominator, namely, the total population (15 years age and older), resulting from differences in fertility rates by skill level. Given the age structure of new immigrants between 25 and 64, the increase was even more pronounced for the working-age population, that is, between 13.1% and 14.4% in 2060 depending upon the policy's degree of selectivity. Consequently, these inflows allow a substantial alteration of the skill distribution of immigrants in the country (Table 3). If the *non-selective immigration* scenario leaves, by construction, the immigrants' skills virtually unchanged, both selective policies improve the skill distribution of immigrants. The *selective immigration* scenario leads to a share of highly-skilled immigrants almost identical to those of natives in 2040. With the *neutral immigration* policy, the difference is relatively low between the two populations and stabilizes at 3% for the highly-skilled beginning in 2040.

What are the effects of the immigration policies on the dependency ratio ? Table 6 indicates that these important changes in the composition of the French population will eventually result in a relatively moderate improvement in the dependency ratio. However, the reduction is temporary. It reaches its maximum improvement level in 2040, with a drop of approximately 3 percentage points. Note that the gain is greater with a *non-selective policy*. *Neutral immigration* and *selective immigration* scenarios actually lead to a deterioration in this ratio from 2080, while the *non-selective* scenario still has a positive but limited (-0.2 percentage points) effect at the end of the century. These opposite effects, depending upon the level of selectivity of the policy, are again explained by the differentiation of the demographic parameters of each skill category. Part of the explanation lies in the fertility rate. The growth of the labor force over the length of the simulation is more important with a non-selective policy. Another part of the explanation lies in the fact that skilled individuals have a higher life expectancy than non-skilled individuals. This explains why the effects are similar at the beginning of the simulation but differ when additional immigrants age.

5.2 A France without immigration: impact on public finances

If immigration is stopped after 2010, the first effect is the decline in the GDP per capita relative to the baseline (Table 7). As we saw in the previous section, a negative demographic shock affects the working population more than the population as a whole. Indeed, inflows consist in a systematically younger population than the entire French population. Their removal affects more people of working age and, thus, the numerator in the ratio that determines the GDP per capita. Secondly, these inflows are consistently less skilled than the population already present in the country. Stopping immigration then also has the effect of increasing the skilled labor force and, thus, the average human capital per worker. The immediate effect on the labor market is that skilled labor is more abundant, and its relative wage decreases.

- Insert Table 7 -

However, the more important consequences are at the funding level for social welfare. The reduction in the GDP and the increasing dependency ratio both cause increased expenditures in social welfare as a percentage of the GDP. Compared to the baseline, the scenario without immigration leads to increased spending by 1.1 point of the GDP in 2060 and more than 2 points by the end of the century. It implies an increase in financing needs. This amounts to 2.9% in 2060 and 3.4% in 2100 versus 1.9% and 1.4% respectively in the baseline. If we examine more closely the various pillars of social welfare, Table 8 suggests that funds that are affected by this immigration policy are those that are most sensitive to the age distribution of the population: pensions and health care expenditures. The breakdown of the increased financing needs of social protection in 2060 is as follows: pensions -1.1%, health care -0.2%, family housing 0.2%, unemployment 0%, and social assistance 0.1%. The degradation of the finances of retirement is thus the main source of the overall effect. To conclude, immigration contributes to reducing the tax burden of aging, and the overall impact is, therefore, unequivocally positive on the finances of social protection in France.

- Insert Table 8 -

5.3 The contribution of a selective immigration policy to finance social protection

The macroeconomic consequences of a more ambitious immigration policy are described in Table 7. The demographic shock is symmetric to that specified in the scenario without immigration. However, the effects differ somewhat due to the predominantly transitory positive impact on the dependency ratio, which is very sensitive to the skills distribution of new immigrants.

The selective policies translate to an increase (compared to the baseline scenario) of the average human capital per worker over the period, while the *non-selective policy* leads to a moderate reduction in this variable. These developments with respect to skill level explain, systematically, the reduction of the wage gap in the case of selective policies as well as the improvement with a *non-selective policy*. This improvement of human capital, in the case

of selective policies, explains the moderate increase in the GDP per capita throughout the period.

The impact of these ambitious migration policies on public finances is variable according to the period and to the degree of selectivity (Table 7 and 8). The reduction of social transfers is more pronounced at mid-century, with a decrease of 1.8 point of the GDP for the more selective policy and 1.4 point for a non-selective policy in 2040. The aging of additional incoming immigrants progressively limits the benefits and inverts the hierarchy of the different policies. These three immigration policies reduced the social transfers by around 1 point of the GDP at the end of the century. This reduction in public transfers leads to a reduction of the tax burden of aging: these gains in terms of financing needs are much higher at the beginning of the period that the policy is selective. Gradually, the effects tend to be reversed.

These differentiated effects according to the degree of selectivity of migratory policy moves essentially through retirement (Table 8). Regarding the pensions, the additional flows of immigrants, regardless of the distribution of skills, increase, in the short term, the number of contributors and change very little the number and distribution of inactive workers and the total amount of pensions. In the longer term, additional flows of older immigrants result in an increase in pensions, which is especially important as these new retirees are skilled. With selective policies, the revenues of contributors improve slightly, while in the medium term, the combination of a lower birth rate and a higher life expectancy outweighs the financial gains allowed by a non-selective policy. Finally, lower fertility among skilled immigrants associated with longer life expectancy tend to pretty mitigate long-term beneficial effects of selective immigration policy.

6 Conclusion

Immigration has many effects, most of which are generally positive, on the finances of social welfare in France. We have shown that immigration, as projected in official forecasts, reduces the tax burden of an aging population. In the absence of immigration, the financing need of social welfare increased by 1 points of GDP at the mid century. These benefits are mainly the result of the age distribution of net flows, younger than French population as a whole, and principally affect, not surprisingly, the two pillars of social protection most sensitive to demographic changes: pensions and health care.

For similar reasons, a more ambitious immigration policy would contribute to reducing the tax burden of an aging population. However, the financial gains are relatively moderate in comparison to the demographic changes it implies. These changes include a significant reduction of this burden for a growing workforce of between 19.6% and 22.8%, depending on its degree of selectivity, while the proportion of immigrants in this population would double by the end of the century.

A more selective policy in favor of skilled workers can amplify these gains in the short to medium term while reducing demographic changes but in proportions that remain relatively low. Most importantly, and contrary to popular belief in the social debate, this improvement is temporary. In the longer term, demographic changes of a more selective immigration policy outweigh its positive effects when compared to a non-selective policy.

However, even if this paper allows to evaluate whether immigration can alleviate the fiscal burden facing the french economy, we have nonetheless to remain cautious regarding the relative simplicity of our model compared to the complexity of the issues raised by immigration. Firstly, the question of the assimilation of migrants must be placed at the heart of the debate. Indeed, by distinguishing only natives and immigrants, our model leaves aside the question of integration difficulties that can meet the children of immigrants (the second generation immigrants). Then, our conclusion could be nuanced by considering various externalities associated to human capital accumulation. For example, we assume that the effect of immigration on the average level of education has no effect on technical changes (especially skill-biased technical changes). Assuming a relationship between the average level of education and skill biases would probably alter the results when considering selective migration policy. Finally, endogenizing technical changes also appears as a promising issue. Indeed, beyond the effects already integrated into our model, a recent literature emphasizes the positive effect of a strong diversity of skilled immigrants in richer countries (Alesina, Harnoss & Rapoport (2013)). We leave these issues for further research.

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Table 1: Baseline calibration of the model

Parameters			
		Value	Source
φ	Labor share in output	0.7	Insee
μ	Scale parameter in production function	0.5	Calibration
ρ	Elasticity of substitution between labor, education and experience	0.7	
d	Depreciation rate of capital (10 years)	0.4	
θ_e^1	Depreciation rate of experience	0.737	Wasmer (2001b)
ψ	Elasticity of substitution of educational capital to investment in education	0.75	Calibration
ϵ	Scale parameter in the production function of human capital	1.2	Calibration
η_M	Relative pension of an immigrant	0.83	BdF(2006)
a_u	Long term elasticity of the cost of labor to the unemployment rate	-1.2	d'Autume & Quinet (2001)
$\underline{\lambda}$	Lower bounds of the skill distribution	-34.9	OLS regression
$\overline{\lambda}$	Upper bounds of the skill distribution	39.7	OLS regression
Observed exogenous process			
α_{t+4}	Elderly participation rate	Blondal & Scarpetta (1997) and COR(2012)	
q_t	Overall participation rates	Wasmer (2001b)	
τ_t^k	Tax rate on consumption	Insee (2009)	
τ_t^c	Tax rate on capital income	Insee (2009)	
cot_t^{risque}	Rates of social contributions	Insee (2009)	
csg_t^{risque}	Taxes earmarked for social protection	Insee (2009)	
D_t	Ratio of debt to GDP	OECD	
ϑ_t	Share of public expenditures in GDP	OECD	
$\gamma^S_{risque,X,j}$	Age-specific transfers	Chojnicki (2013)	
v_t	Rate of subsidy on tertiary education	De la Croix & Docquier (2007)	

Table 2: French population in the baseline (2010-2100)

	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2100**
Total population *(thousands)*	65,339	68,219	70,753	73,014	74,836	76,509	82,334
Working-age population *(15-64 years, in thousands)*	41,189	41,052	40,996	41,060	41,746	42,525	45,848
Share of immigrants *(in % of total population)*	8.3%	8.6%	8.9%	9.0%	8.9%	8.8%	7.8%
Old age dependency ratio *(65 years and more / 15-64 years in %)*	27.7%	34.5%	40.9%	45.6%	46.4%	47.2%	46.9%

Source: authors' calculations

Table 3: Skill distribution of the working-age population (2010-2100)

	2010	2020	2030	2040	2050	2060	2100
Baseline							
High skilled (15-64 years)							
Natives (a)	32.4%	37.1%	41.1%	43.1%	43.1%	43.1%	43.1%
Immigrants (b)	25.1%	28.5%	31.3%	33.2%	33.2%	33.2%	33.2%
Total population (c)	**31.7%**	**36.2%**	**40.1%**	**42.1%**	**42.2%**	**42.2%**	**42.3%**
Low skilled (15-64 years)							
Natives (a)	49.1%	42.7%	37.2%	34.2%	34.2%	34.2%	34.2%
Immigrants (b)	60.5%	55.4%	51.5%	49.1%	49.0%	49.0%	49.0%
Total population (c)	**50.3%**	**44.0%**	**38.7%**	**35.7%**	**35.6%**	**35.5%**	**35.4%**
Without immig.							
High skilled (15-64 years)							
Natives (a)	32.4%	37.1%	41.1%	43.1%	43.2%	43.2%	43.4%
Immigrants (b)	24.9%	27.5%	30.2%	33.2%	33.2%	33.3%	-
Total population (c)	**31.7%**	**36.3%**	**40.5%**	**42.8%**	**43.0%**	**43.2%**	**43.4%**
Low skilled (15-64 years)							
Natives (a)	49.1%	42.7%	37.3%	34.2%	34.2%	34.2%	34.2%
Immigrants (b)	60.8%	56.7%	53.0%	49.0%	48.9%	48.9%	-
Total population (c)	**50.3%**	**43.8%**	**38.2%**	**34.7%**	**34.4%**	**34.3%**	**34.2%**
Non selective immig.							
High skilled (15-64 years)							
Natives (a)	32.4%	37.1%	41.1%	43.0%	42.9%	42.9%	42.9%
Immigrants (b)	25.3%	29.2%	31.7%	33.2%	33.2%	33.2%	33.2%
Total population (c)	**31.7%**	**36.0%**	**39.6%**	**41.3%**	**41.3%**	**41.3%**	**41.4%**
Low skilled (15-64 years)							
Natives (a)	49.1%	42.7%	37.2%	34.2%	34.2%	34.2%	34.2%
Immigrants (b)	60.2%	54.5%	51.0%	49.0%	49.0%	49.0%	49.0%
Total population (c)	**50.3%**	**44.3%**	**39.4%**	**36.8%**	**36.7%**	**36.7%**	**36.5%**
Neutral immig.							
High skilled (15-64 years)							
Natives (a)	32.5%	37.1%	41.1%	43.0%	42.9%	42.9%	42.9%
Immigrants (b)	25.6%	32.7%	37.2%	39.8%	40.3%	40.3%	40.6%
Total population (c)	**31.7%**	**36.5%**	**40.5%**	**42.5%**	**42.5%**	**42.4%**	**42.5%**
Low skilled (15-64 years)							
Natives (a)	49.1%	42.7%	37.2%	34.2%	34.2%	34.2%	34.2%
Immigrants (b)	60.0%	49.3%	42.7%	38.7%	38.5%	38.4%	38.0%
Total population (c)	**50.3%**	**43.6%**	**38.1%**	**35.0%**	**34.9%**	**34.9%**	**34.8%**
Selective immig.							
High skilled (15-64 years)							
Natives (a)	32.5%	37.1%	41.1%	43.0%	42.9%	42.9%	42.9%
Immigrants (b)	29.0%	36.8%	40.7%	42.5%	43.2%	43.2%	43.2%
Total population (c)	**32.1%**	**37.1%**	**41.0%**	**42.9%**	**43.0%**	**42.9%**	**43.0%**
Low skilled (15-64 years)							
Natives (a)	49.1%	42.7%	37.2%	34.2%	34.2%	34.2%	34.2%
Immigrants (b)	55.1%	43.3%	37.4%	34.8%	34.1%	34.1%	34.1%
Total population (c)	**49.8%**	**42.8%**	**37.3%**	**34.3%**	**34.2%**	**34.2%**	**34.2%**

(a) in percentage of total natives (15-64 years)
(b) in percentage of total immigrants (15-64 years)
(c) in percentage of total population (15-64 years)
Source: authors' calculations.

Table 4: Main macroeconomic aggregates - Baseline (2010-2100)

	2010	2020	2030	2040	2050	2060	2100
GDP per capita (1 in 2010)	1.00	1.10	1.26	1.38	1.62	1.91	3.30
Social protection expenditures (in % of GDP)	30.4%	30.6%	30.6%	31.6%	31.8%	31.9%	31.4%
Financing needs of social protection (in % of GDP)	-0.7%	-0.5%	-0.3%	-1.4%	-1.7%	-1.9%	-1.4%
Unemployment rate (in %)	9.1%	6.2%	4.5%	4.5%	4.5%	4.5%	4.5%
Average human capital per worker (1 en 2010)	1.000	1.137	1.232	1.279	1.277	1.277	1.279
Average experience per worker (1 en 2010)	1.000	1.042	1.060	1.058	1.060	1.062	1.058
Wage gap at age 45 (High skilled/Low skilled)	2.03	2.03	2.03	2.03	2.03	2.03	2.03
Average wage for 15-65 years (1 en 2010)	1.000	1.260	1.522	1.722	2.018	2.450	4.314
Return on capital (annual real interest rate - in %)	2.68%	3.13%	3.10%	3.62%	3.63%	4.16%	4.00%

(a) Percentage points of change compared to the baseline
(b) Change in percent of the baseline
Source: Authors' calculations

Table 5: Social protection (baseline, 2010-2100)

	2010	2020	2030	2040	2050	2060	2100
Social protection expenditures *(in % of GDP)*	30.4%	30.6%	30.6%	31.6%	31.8%	31.9%	31.4%
Social contributions *(in % of GDP)*	20.9%	21.1%	21.1%	21.0%	20.9%	20.8%	20.8%
General Social Contribution (CSG) *(in % of GDP)*	6.6%	6.8%	6.8%	6.9%	6.8%	6.9%	6.8%
Public contributions *(in % of GDP)*	2.2%	2.3%	2.3%	2.4%	2.3%	2.3%	2.3%
Financing needs *(in % of GDP)*	-0.7%	-0.5%	-0.3%	-1.4%	-1.7%	-1.9%	-1.4%
Retirement (in % of GDP)							
- *Expenditures*	13.8%	14.1%	13.9%	13.8%	13.5%	13.3%	12.9%
- *Financing needs*	-0.7%	-1.0%	-0.9%	-0.8%	-0.6%	-0.5%	-0.1%
Health (in % of GDP)							
- *Expenditures*	11.0%	11.7%	12.5%	13.5%	14.1%	14.2%	14.2%
- *Financing needs*	0.0%	-0.5%	-1.1%	-2.2%	-2.8%	-2.9%	-3.0%
Family-Housing (in % of GDP)							
- *Expenditures*	3.6%	3.3%	3.1%	3.1%	3.1%	3.2%	3.2%
- *Financing needs*	0.0%	0.4%	0.6%	0.6%	0.6%	0.5%	0.5%
Unemployment (in % of GDP)							
- *Expenditures*	1.9%	1.2%	0.8%	0.8%	0.8%	0.9%	0.8%
- *Financing needs*	0.0%	0.6%	0.9%	0.9%	0.9%	0.9%	0.9%
Sociale assistance (in % of GDP)							
- *Expenditures*	0.6%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%
- *Financing needs*	0.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%

Source: authors' calculations.

Table 6: French population structure under alternative scenarios (2010-2100)

		2010	2020	2030	2040	2050	2060	2100
Population (15 years and more)	Baseline	53,202	55,740	58,236	60,145	61,196	62,486	67,251
(Thousands)	*Without immig. (b)*	**-0.3%**	**-1.9%**	**-3.7%**	**-5.8%**	**-8.3%**	**-10.9%**	**-21.1%**
	Non selective immig. (b)	**0.5%**	**2.8%**	**5.1%**	**8.0%**	**10.9%**	**13.7%**	**22.7%**
	Neutral immig. (b)	**0.5%**	**2.8%**	**5.0%**	**7.7%**	**10.5%**	**13.1%**	**21.0%**
	Selective immig. (b)	**0.5%**	**2.8%**	**5.0%**	**7.6%**	**10.3%**	**12.8%**	**20.1%**
Working age population	Baseline	41966	41859	41826	41883	42595	43406	46789
(Thousands)	*Without immig. (b)*	**-0.4%**	**-2.6%**	**-5.0%**	**-7.9%**	**-10.5%**	**-13.1%**	**-23.2%**
	Non selective immig. (b)	**0.6%**	**3.6%**	**6.7%**	**10.3%**	**12.5%**	**14.4%**	**22.8%**
	Neutral immig. (b)	**0.6%**	**3.6%**	**6.6%**	**10.0%**	**12.0%**	**13.5%**	**20.7%**
	Selective immig. (b)	**0.6%**	**3.6%**	**6.5%**	**9.8%**	**11.7%**	**13.1%**	**19.6%**
Annual net migration flows	Baseline	100	100	100	100	100	100	100
(Thousands)	*Without immig.*	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Non selective immig.	**225**	**235**	**244**	**252**	**258**	**264**	**284**
	Neutral immig.	**225**	**235**	**244**	**252**	**258**	**264**	**284**
	Selective immig.	**225**	**235**	**244**	**252**	**258**	**264**	**284**
Share of immigrants	Baseline	9.8%	10.2%	10.5%	10.5%	10.5%	10.3%	9.1%
(in % of population aged 15 years and more)	*Without immig. (a)*	**-0.3%**	**-1.7%**	**-3.3%**	**-4.7%**	**-6.1%**	**-7.4%**	**-9.1%**
	Non selective immig. (a)	**0.4%**	**2.4%**	**4.2%**	**5.7%**	**7.1%**	**8.3%**	**8.9%**
	Neutral immig. (a)	**0.4%**	**2.4%**	**4.2%**	**5.8%**	**7.2%**	**8.4%**	**9.2%**
	Selective immig. (a)	**0.4%**	**2.4%**	**4.2%**	**5.8%**	**7.3%**	**8.5%**	**9.3%**
Old age dependency ratio	Baseline	26.8%	33.2%	39.2%	43.6%	43.7%	44.0%	43.7%
(Pop 65+ / Pop 15-64 in %)	*Without immig. (a)*	**0.1%**	**0.9%**	**2.0%**	**3.3%**	**3.4%**	**3.6%**	**4.1%**
	Non selective immig. (a)	**-0.2%**	**-1.0%**	**-2.1%**	**-3.0%**	**-2.1%**	**-0.9%**	**-0.2%**
	Neutral immig. (a)	**-0.2%**	**-1.0%**	**-2.0%**	**-2.9%**	**-1.9%**	**-0.5%**	**0.3%**
	Selective immig. (a)	**-0.2%**	**-1.0%**	**-2.0%**	**-2.8%**	**-1.7%**	**-0.3%**	**0.6%**

(a) Percentage points of change compared to the baseline
(b) Change in percent of the baseline
Source: Authors' calculations.

Table 7: Main macroeconomic aggregates - alternative migratory scenarios (2010-2100)

	2010	2020	2030	2040	2050	2060	2100
GDP per capita (1 in 2010)							
Without immig. (b)	**0.0%**	**-0.8%**	**-0.5%**	**-1.7%**	**-1.3%**	**-1.7%**	**-3.4%**
Non selective immig. (b)	**0.0%**	**0.6%**	**2.0%**	**2.9%**	**1.2%**	**2.3%**	**1.7%**
Neutral immig. (b)	**0.0%**	**0.9%**	**2.6%**	**4.4%**	**2.3%**	**3.2%**	**2.7%**
Selective immig. (b)	**0.0%**	**4.1%**	**3.4%**	**4.0%**	**4.0%**	**2.8%**	**0.2%**
Social protection expenditures (in % of GDP)							
Without immig. (a)	**0.1%**	**0.5%**	**0.4%**	**1.0%**	**1.0%**	**1.1%**	**2.1%**
Non selective immig. (a)	**-0.1%**	**-0.2%**	**-0.8%**	**-1.4%**	**-0.5%**	**-0.9%**	**-0.9%**
Neutral immig. (a)	**-0.1%**	**-0.3%**	**-0.9%**	**-1.8%**	**-0.8%**	**-0.9%**	**-1.0%**
Selective immig. (a)	**-0.1%**	**-0.4%**	**-1.0%**	**-1.8%**	**-0.9%**	**-0.9%**	**-0.9%**
Financing needs of social protection (in % of GDP)							
Without immig. (a)	**-0.1%**	**-0.5%**	**-0.4%**	**-1.0%**	**-0.9%**	**-1.0%**	**-2.0%**
Non selective immig. (a)	**0.1%**	**0.1%**	**0.7%**	**1.3%**	**0.4%**	**0.8%**	**0.8%**
Neutral immig. (a)	**0.1%**	**0.3%**	**0.8%**	**1.7%**	**0.6%**	**0.7%**	**0.9%**
Selective immig. (a)	**0.1%**	**0.3%**	**0.8%**	**1.7%**	**0.7%**	**0.7%**	**0.7%**
Unemployment rate (in %)							
Without immig. (a)	**0.0%**	**0.1%**	**0.0%**	**0.1%**	**0.1%**	**0.2%**	**0.4%**
Non selective immig. (a)	**-0.1%**	**0.0%**	**-0.1%**	**-0.2%**	**-0.1%**	**-0.2%**	**-0.2%**
Neutral immig. (a)	**-0.1%**	**-0.1%**	**-0.2%**	**-0.4%**	**-0.2%**	**-0.3%**	**-0.3%**
Selective immig. (a)	**-0.1%**	**-0.1%**	**-0.2%**	**-0.4%**	**-0.3%**	**-0.3%**	**-0.3%**
Average human capital per worker (1 en 2010)							
Without immig. (b)	**0.0%**	**0.6%**	**0.9%**	**1.8%**	**2.0%**	**2.3%**	**2.4%**
Non selective immig. (b)	**0.0%**	**-0.5%**	**-0.9%**	**-1.6%**	**-1.5%**	**-1.7%**	**-1.6%**
Neutral immig. (b)	**0.0%**	**0.5%**	**1.0%**	**0.5%**	**0.8%**	**0.5%**	**0.5%**
Selective immig. (b)	**0.0%**	**0.8%**	**1.2%**	**0.7%**	**0.9%**	**0.7%**	**0.6%**
Average experience per worker (1 en 2010)							
Without immig. (b)	**0.0%**	**0.5%**	**0.2%**	**0.4%**	**0.6%**	**1.0%**	**1.0%**
Non selective immig. (b)	**0.0%**	**-0.3%**	**0.7%**	**1.3%**	**1.2%**	**0.9%**	**1.2%**
Neutral immig. (b)	**0.0%**	**-0.5%**	**0.6%**	**1.2%**	**1.2%**	**0.8%**	**1.1%**
Selective immig. (b)	**0.0%**	**-0.5%**	**0.6%**	**1.2%**	**1.2%**	**0.9%**	**1.2%**
Wage gap at age 45 (High skilled/Low skilled)							
Without immig. (a)	**0.0%**	**-0.1%**	**-0.2%**	**-0.4%**	**-0.4%**	**-0.5%**	**-0.5%**
Non selective immig. (a)	**0.0%**	**0.0%**	**0.1%**	**0.3%**	**0.2%**	**0.3%**	**0.3%**
Neutral immig. (a)	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**
Selective immig. (a)	**-0.2%**	**-0.3%**	**-0.3%**	**-0.2%**	**-0.2%**	**-0.2%**	**-0.2%**
Average wage for 15-65 years (1 en 2010)							
Without immig. (b)	**0.0%**	**0.9%**	**4.2%**	**5.3%**	**7.5%**	**7.6%**	**2.7%**
Non selective immig. (b)	**0.0%**	**-0.9%**	**-0.1%**	**-0.3%**	**-3.1%**	**-0.7%**	**-0.2%**
Neutral immig. (b)	**0.0%**	**-0.5%**	**0.4%**	**1.4%**	**-1.9%**	**-0.2%**	**0.4%**
Selective immig. (b)	**0.0%**	**-0.4%**	**0.7%**	**1.8%**	**-1.1%**	**0.3%**	**0.3%**
Return on capital (annual real interest rate - in %)							
Without immig. (a)	**0.0%**	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**0.0%**
Non selective immig. (a)	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.1%**	**-0.1%**	**-0.1%**
Neutral immig. (a)	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.1%**	**-0.1%**	**-0.1%**
Selective immig. (a)	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.1%**	**-0.1%**	**-0.1%**

(a) Percentage points of change compared to the baseline

(b) Change in percent of the baseline

Source: Authors' calculations

Table 8: Social protection - alternative migratory scenarios (2010-2100)

	2010	2020	2030	2040	2050	2060	2100
Retirement (in % of GDP)							
			Expenditures				
Without Immig.	**0.1%**	**0.4%**	**0.5%**	**0.9%**	**0.9%**	**1.1%**	**1.5%**
Non selective immig.	**-0.1%**	**-0.4%**	**-0.8%**	**-1.0%**	**-0.7%**	**-0.8%**	**-0.5%**
Neutral immig.	**-0.1%**	**-0.5%**	**-0.9%**	**-1.1%**	**-0.7%**	**-0.7%**	**-0.4%**
Selective immig.	**-0.1%**	**-0.5%**	**-0.9%**	**-1.1%**	**-0.7%**	**-0.6%**	**-0.3%**
			Financing needs				
Without Immig.	**-0.1%**	**-0.4%**	**-0.5%**	**-0.9%**	**-0.9%**	**-1.1%**	**-1.5%**
Non selective immig.	**0.1%**	**0.4%**	**0.8%**	**1.0%**	**0.7%**	**0.7%**	**0.5%**
Neutral immig.	**0.2%**	**0.5%**	**0.9%**	**1.1%**	**0.7%**	**0.6%**	**0.3%**
Selective immig.	**0.1%**	**0.5%**	**0.9%**	**1.1%**	**0.7%**	**0.6%**	**0.3%**
Health (in % of GDP)							
			Expenditures				
Without Immig.	**0.0%**	**0.2%**	**0.1%**	**0.3%**	**0.3%**	**0.2%**	**0.8%**
Non selective immig.	**0.0%**	**0.1%**	**-0.2%**	**-0.5%**	**0.0%**	**-0.3%**	**-0.5%**
Neutral immig.	**0.0%**	**0.1%**	**-0.1%**	**-0.7%**	**-0.2%**	**-0.3%**	**-0.6%**
Selective immig.	**0.0%**	**0.1%**	**-0.1%**	**-0.7%**	**-0.2%**	**-0.3%**	**-0.6%**
			Financing needs				
Without Immig.	**0.0%**	**-0.2%**	**0.0%**	**-0.3%**	**-0.2%**	**-0.2%**	**-0.7%**
Non selective immig.	**0.0%**	**-0.1%**	**0.1%**	**0.5%**	**0.0%**	**0.2%**	**0.5%**
Neutral immig.	**0.0%**	**-0.1%**	**0.1%**	**0.7%**	**0.1%**	**0.2%**	**0.6%**
Selective immig.	**0.0%**	**-0.1%**	**0.1%**	**0.6%**	**0.2%**	**0.3%**	**0.5%**
Family-Housing (in % of GDP)							
			Expenditures				
Without Immig.	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.2%**	**-0.2%**	**-0.2%**
Non selective immig.	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.2%**	**0.1%**	**0.1%**
Neutral immig.	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**
Selective immig.	**0.0%**	**0.1%**	**0.1%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
			Financing needs				
Without Immig.	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.2%**	**0.2%**	**0.2%**
Non selective immig.	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.2%**	**-0.1%**	**-0.1%**
Neutral immig.	**0.0%**	**-0.1%**	**-0.1%**	**0.0%**	**-0.1%**	**-0.1%**	**0.0%**
Selective immig.	**0.0%**	**-0.1%**	**-0.1%**	**0.0%**	**-0.1%**	**0.0%**	**0.0%**
Unemployment (in % of GDP)							
			Expenditures				
Without Immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Non selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Neutral immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
			Financing needs				
Without Immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**-0.1%**
Non selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Neutral immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Sociale assistance (in % of GDP)							
			Expenditures				
Without Immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**
Non selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**
Neutral immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.0%**	**0.0%**
Selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
			Financing needs				
Without Immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**0.1%**	**0.1%**
Non selective immig.	**0.0%**	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**
Neutral immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**-0.1%**	**0.0%**	**0.0%**
Selective immig.	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

Percentage points of change compared to the baseline
Source: Authors' calculations

Table 9: Economic consequences of immigration (lower elasticity of substitution, $\rho = 0.5$)

	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2100**
GDP per capita (1 in 2010)							
Baseline	1.00	1.11	1.27	1.39	1.63	1.92	3.29
Without immig. (b)	**0.0%**	**-0.8%**	**-0.5%**	**-1.7%**	**-1.2%**	**-1.7%**	**-3.5%**
Selective immig. (b)	**0.0%**	**1.1%**	**2.7%**	**4.5%**	**2.5%**	**3.2%**	**2.6%**
Social protection expenditures (in % of GDP)							
Baseline	30.4%	30.2%	30.0%	30.9%	31.1%	31.2%	31.6%
Without immig. (a)	**0.1%**	**0.5%**	**0.5%**	**1.0%**	**1.0%**	**1.1%**	**2.3%**
Selective immig. (a)	**-0.1%**	**-0.4%**	**-1.0%**	**-1.8%**	**-0.8%**	**-0.9%**	**-0.9%**
Financing needs of social protection (in % of GDP)							
Baseline	-0.7%	-0.2%	0.1%	-0.9%	-1.2%	-1.5%	-1.8%
Without immig. (a)	**-0.1%**	**-0.5%**	**-0.4%**	**-1.0%**	**-0.9%**	**-1.0%**	**-2.1%**
Selective immig. (a)	**0.1%**	**0.3%**	**0.9%**	**1.6%**	**0.7%**	**0.7%**	**0.8%**
Unemployment rate (in %)							
Baseline	9.1%	6.2%	4.5%	4.5%	4.5%	4.5%	4.5%
Without immig. (a)	**0.0%**	**0.1%**	**0.0%**	**0.1%**	**0.1%**	**0.2%**	**0.4%**
Selective immig. (a)	**-0.1%**	**-0.1%**	**-0.2%**	**-0.4%**	**-0.2%**	**-0.3%**	**-0.3%**
Average human capital per worker (1 in 2010)							
Baseline	1.000	1.137	1.232	1.279	1.277	1.277	1.279
Without immig. (b)	**0.0%**	**0.6%**	**0.9%**	**1.8%**	**2.0%**	**2.3%**	**2.5%**
Selective immig. (b)	**0.0%**	**0.8%**	**1.2%**	**0.7%**	**0.9%**	**0.7%**	**0.6%**
Average experience per worker (1 in 2010)							
Baseline	1.000	1.042	1.060	1.058	1.060	1.062	1.058
Without immig. (b)	**0.0%**	**0.5%**	**0.2%**	**0.4%**	**0.6%**	**1.0%**	**1.0%**
Selective immig. (b)	**0.0%**	**-0.5%**	**0.6%**	**1.2%**	**1.2%**	**0.9%**	**1.2%**
Wage gap at age 45 (High skilled/Low skilled)							
Baseline	2.03	2.03	2.03	2.03	2.03	2.03	2.03
Without immig. (a)	**0.0%**	**-0.1%**	**-0.3%**	**-0.7%**	**-0.7%**	**-0.8%**	**-0.8%**
Selective immig. (a)	**-0.3%**	**-0.5%**	**-0.5%**	**-0.3%**	**-0.3%**	**-0.3%**	**-0.3%**
Average wage for 15-65 years (1 in 2010)							
Baseline	1.000	1.214	1.447	1.664	1.952	2.347	3.936
Without immig. (b)	**0.0%**	**0.9%**	**4.2%**	**5.3%**	**7.6%**	**7.7%**	**2.1%**
Selective immig. (b)	**0.0%**	**-0.4%**	**0.7%**	**1.6%**	**-1.3%**	**0.1%**	**0.4%**

(a) Percentage points of change compared to the baseline
(b) Change in percent of the baseline
Source: Authors' calculations

Table 10: Economic consequences of immigration (lower elasticity of substitution, $\rho = 0.9$)

	2010	**2020**	**2030**	**2040**	**2050**	**2060**	**2100**
GDP per capita (1 in 2010)							
Baseline	1.00	1.10	1.26	1.38	1.61	1.90	3.31
Without immig. (b)	**0.0%**	**-0.8%**	**-0.5%**	**-1.8%**	**-1.3%**	**-1.8%**	**-3.4%**
Selective immig. (b)	**0.0%**	**1.1%**	**2.8%**	**4.6%**	**2.7%**	**3.4%**	**2.6%**
Social protection expenditures (in % of GDP)							
Baseline	30.4%	30.8%	30.9%	32.1%	32.3%	32.4%	31.3%
Without immig. (a)	**0.1%**	**0.5%**	**0.4%**	**1.0%**	**1.0%**	**1.1%**	**2.1%**
Selective immig. (a)	**-0.1%**	**-0.4%**	**-1.0%**	**-1.8%**	**-0.9%**	**-0.9%**	**-0.8%**
Financing needs of social protection (in % of GDP)							
Baseline	-0.7%	-0.6%	-0.6%	-1.7%	-2.1%	-2.2%	-1.3%
Without immig. (a)	**-0.1%**	**-0.5%**	**-0.4%**	**-1.0%**	**-0.9%**	**-1.0%**	**-1.9%**
Selective immig. (a)	**0.1%**	**0.3%**	**0.8%**	**1.7%**	**0.7%**	**0.8%**	**0.7%**
Unemployment rate (in %)							
Baseline	9.1%	6.2%	4.5%	4.5%	4.5%	4.5%	4.5%
Without immig. (a)	**0.0%**	**0.1%**	**0.0%**	**0.1%**	**0.1%**	**0.2%**	**0.3%**
Selective immig. (a)	**-0.1%**	**-0.1%**	**-0.2%**	**-0.4%**	**-0.3%**	**-0.3%**	**-0.3%**
Average human capital per worker (1 in 2010)							
Baseline	1.000	1.137	1.232	1.279	1.277	1.277	1.279
Without immig. (b)	**0.0%**	**0.6%**	**0.9%**	**1.8%**	**2.0%**	**2.3%**	**2.4%**
Selective immig. (b)	**0.0%**	**0.8%**	**1.2%**	**0.7%**	**0.9%**	**0.7%**	**0.6%**
Average experience per worker (1 in 2010)							
Baseline	1.000	1.042	1.060	1.058	1.060	1.062	1.058
Without immig. (b)	**0.0%**	**0.5%**	**0.2%**	**0.4%**	**0.6%**	**1.0%**	**0.9%**
Selective immig. (b)	**0.0%**	**-0.5%**	**0.6%**	**1.2%**	**1.2%**	**0.9%**	**1.2%**
Wage gap at age 45 (High skilled/Low skilled)							
Baseline	2.03	2.03	2.03	2.03	2.03	2.03	2.03
Without immig. (a)	**0.0%**	**0.0%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.2%**	**-0.2%**
Selective immig. (a)	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**	**-0.1%**
Average wage for 15-65 years (1 in 2010)							
Baseline	1.000	1.219	1.437	1.632	1.897	2.288	4.044
Without immig. (b)	**0.0%**	**1.0%**	**4.3%**	**5.3%**	**7.5%**	**7.6%**	**3.0%**
Selective immig. (b)	**0.0%**	**-0.4%**	**0.7%**	**1.9%**	**-1.0%**	**0.4%**	**0.3%**

(a) Percentage points of change compared to the baseline
(b) Change in percent of the baseline
Source: Authors' calculations

Table 11: Economic consequences of immigration (Partial equilibrium model)

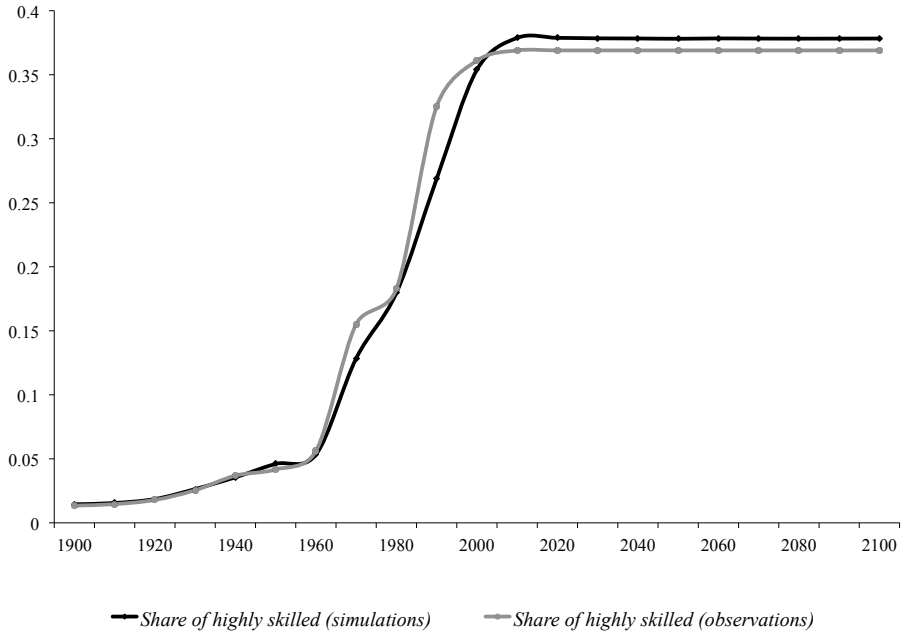
	2010	2020	2030	2040	2050	2060	2100
GDP per capita (1 in 2010)							
Without immig. (b)	**-0.1%**	**-0.8%**	**-0.3%**	**-1.6%**	**-1.2%**	**-2.0%**	**-5.7%**
Non selective immig. (b)	**0.0%**	**0.4%**	**1.9%**	**3.1%**	**1.6%**	**3.5%**	**4.1%**
Neutral immig. (b)	**0.1%**	**0.8%**	**2.5%**	**4.8%**	**3.1%**	**4.9%**	**5.7%**
Selective immig. (b)	**0.2%**	**1.1%**	**2.8%**	**5.2%**	**3.8%**	**5.3%**	**5.8%**
Social protection expenditures (in % of GDP)							
Without immig. (a)	**0.1%**	**0.5%**	**0.4%**	**0.9%**	**0.9%**	**1.0%**	**2.8%**
Non selective immig. (a)	**0.0%**	**-0.1%**	**-0.7%**	**-1.3%**	**-0.5%**	**-1.0%**	**-1.6%**
Neutral immig. (a)	**-0.1%**	**-0.2%**	**-0.8%**	**-1.7%**	**-0.8%**	**-1.1%**	**-1.8%**
Selective immig. (a)	**-0.1%**	**-0.2%**	**-0.8%**	**-1.7%**	**-0.9%**	**-1.1%**	**-1.7%**
Financing needs of social protection (in % of GDP)							
Without immig. (a)	**-0.1%**	**-0.5%**	**-0.6%**	**-0.9%**	**-0.9%**	**-0.9%**	**-1.8%**
Non selective immig. (a)	**0.1%**	**0.3%**	**0.8%**	**1.1%**	**0.4%**	**0.4%**	**0.7%**
Neutral immig. (a)	**0.2%**	**0.5%**	**1.0%**	**1.4%**	**0.6%**	**0.4%**	**0.8%**
Selective immig. (a)	**0.2%**	**0.6%**	**1.0%**	**1.4%**	**0.7%**	**0.4%**	**0.7%**
Unemployment rate (in %)							
Without immig. (a)	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.2%**	**0.1%**	**0.3%**
Non selective immig. (a)	**-0.1%**	**-0.1%**	**-0.1%**	**-0.2%**	**-0.1%**	**-0.1%**	**-0.2%**
Neutral immig. (a)	**-0.1%**	**-0.2%**	**-0.2%**	**-0.3%**	**-0.2%**	**-0.2%**	**-0.3%**
Selective immig. (a)	**-0.1%**	**-0.2%**	**-0.2%**	**-0.3%**	**-0.3%**	**-0.2%**	**-0.3%**
Average human capital per worker (1 en 2010)							
Without immig. (b)	**0.0%**	**0.6%**	**0.9%**	**1.7%**	**1.9%**	**2.2%**	**2.2%**
Non selective immig. (b)	**0.1%**	**-0.4%**	**-0.8%**	**-1.4%**	**-1.3%**	**-1.5%**	**-1.3%**
Neutral immig. (b)	**0.3%**	**0.8%**	**1.3%**	**0.9%**	**1.2%**	**1.0%**	**1.0%**
Selective immig. (b)	**1.0%**	**1.8%**	**2.3%**	**1.9%**	**2.1%**	**1.9%**	**1.8%**
Average experience per worker (1 en 2010)							
Without immig. (b)	**0.1%**	**0.6%**	**0.3%**	**0.4%**	**0.7%**	**1.1%**	**1.0%**
Non selective immig. (b)	**-0.1%**	**-0.5%**	**0.6%**	**1.2%**	**1.1%**	**0.8%**	**1.1%**
Neutral immig. (b)	**-0.2%**	**-0.7%**	**0.4%**	**1.0%**	**0.9%**	**0.6%**	**0.9%**
Selective immig. (b)	**-0.3%**	**-0.8%**	**0.3%**	**1.0%**	**0.9%**	**0.7%**	**0.9%**
Wage gap at age 45 (High skilled/Low skilled)							
Without immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Non selective immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Neutral immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Selective immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Average wage for 15-65 years (1 en 2010)							
Without immig. (b)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Non selective immig. (b)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Neutral immig. (b)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Selective immig. (b)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Return on capital (annual real interest rate - in %)							
Without immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Non selective immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Neutral immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Selective immig. (a)	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

(a) Percentage points of change compared to the baseline

(b) Change in percent of the baseline

Source: Authors' calculations

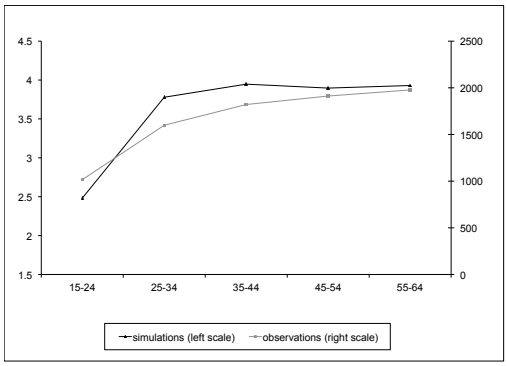
Figure 1: Proportion of students opting for tertiary education



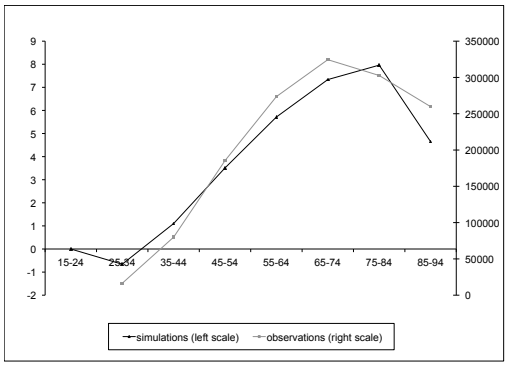
source: Authors' calculation

Figure 2: Wage and asset profiles per ages in 2010 (Baseline scenario)

(a) Wage profile



(b) Asset profile



source: Authors' calculations

A An AGEM-OLG model with heterogeneous agents

This appendix presents the theoretical framework of our AGEM-OLG model with heterogeneous agents.

A.1 Demographics

At each period, the population consists of eight adult cohorts ranging in age from between 15 to 24 years (denoted as cohort 0) to between 85 and 94 years (denoted as cohort 7). One period of the model is 10 years. Cohort t is composed of individuals aged 0 at period t. There are two sources of heterogeneity within each cohort. The first one concerns educational attainment. We distinguish low-skill, medium-skill, and high-skill individuals. These skill levels are respectively denoted by the superscripts $S = L, M, H$. The second one refers to country of origin/birth: we distinguish natives and immigrants (first generation). These categories are respectively denoted by the subscripts $X = N, M$;

At time t, the population aged j ($j = 0, ..., 7$) of skill S ($S = L, M, H$), from origin X ($X = N, M$) is denoted by $P^S_{X,j,t}$. For the sake of simplicity, we assume that individuals give birth to their children at age 30, in the middle of their second adult period of life. Fifteen years after their birth, these children become new adults. Consequently, children born at time t (by adults of cohort $t-1$) reach age 15 at time $t+2$. Fertility differs across skill and origin groups. At time t, the number of children per individual in a specific skill and origin class is denoted by $n^S_{X,t}$. At time t, the proportions of young individuals opting for low, medium, and high education are respectively denoted by π^L_t, π^M_t and π^H_t.

At each period, new immigrants are entering the country. The variable $I^s_{0,t}$ measures the number of young immigrants entering in France at age 0 with a skill level S. At the same time, a proportion of natives and immigrants leaves the country. The variables $\xi^S_{N,j,t}$ and $\xi^S_{M,j,t}$ respectively measure net emigration rates (emigrants minus immigrants compared to the previous period population size) among natives and immigrants of skill S at age j. These rates are positive for natives and they can be positive or negative for immigrants. Finally, some individuals die at each age. We denote by $\beta^S_{j,t}$ ($j = 1, ..., 7$) the proportion of individuals of skill S dying between age $j-1$ and age j.

The dynamic of population is then determined by the set of 48 equations per period (for 8 age groups, 3 skills groups and 2 origins). The number of young natives (aged 15 to 24) of skill S, $P^S_{N,0,t}$, sums up children of natives and immigrants from generation $t-2$ (weighted by the probability to belong to the skill group S). The number of young new immigrants, $P^S_{M,0,t}$, is exogenous:

$$\begin{aligned} P^S_{N,0,t} &= \pi^S_t \sum_{S'} \left[P^{S'}_{N,1,t-2} n^{S'}_{N,t-2} + P^{S'}_{M,1,t-2} n^{S'}_{M,t-2} \right] \\ P^S_{M,0,t} &= I^S_{0,t} \end{aligned}$$

Regarding subsequent age cohorts, we use a simple dynamic process that takes into account mortality changes, in-migration and out-migration. The sizes of cohorts aged 1 to 7 are given by (for $S = L, M, H$ and $X = N, M$):

$$P^S_{X,j,t} = (1 - \beta^S_{j,t})(1 - \xi^S_{X,j,t})P^S_{X,j-1,t-1}$$
$$j = 1, ..., 7$$

A.2 Technology

Rather than considering the existence of multiple labor markets (for the low, medium, and high skilled, for young and old workers, etc.), we assume that workers belonging to different age, skill, and origin groups offer different combinations of schooling and experience. Formally, in each period, a representative firm uses labor in efficiency units (Q_t) and physical capital (K_t) to produce a composite good (Y_t). We consider a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A_t K_t^{1-\varphi} Q_t^{\varphi} \tag{1}$$

where φ measures the share of labor income in national output and A_t denotes an exogenous process determining the total factor productivity. Arising from the mincerian literature on the determination of wages, the amount of labor in efficiency units (Q_t) explicitly aggregates attributes of native workers and immigrants. It is based on the work of Ben-Porath (1967), Card & Lemieux (2001), and Wasmer (2001a). The quantity of efficiency unit of labor combines raw labor, experience, and education according to a CES nested transformation function:

$$Q_t = [L_t^{\rho} + \mu E_t^{\rho} + \Theta_t \, H_t^{\rho}]^{1/\rho} \tag{2}$$

where L_t measures the physical work, E_t represents experience and H_t denotes education. The parameter ρ is the inverse of the elasticity of substitution among these attributes, and μ is a fixed parameter of preference for experience. Finally, Θ_t is an exogenous skill-biased technical progress.

The representative firm behaves competitively on the factor markets[6]. The conditions for profit maximization are:

$$\begin{aligned}
r_t &= (1-\varphi) A_t K_t^{-\varphi} Q_t^{\varphi} - d && (3)\\
w_t^L &= \varphi A_t K_t^{1-\varphi} Q_t^{\varphi-\rho} L_t^{\rho-1} && (4)\\
w_t^E &= \varphi A_t K_t^{1-\varphi} Q_t^{\varphi-\rho} \mu E_t^{\rho-1} && (5)\\
w_t^H &= \varphi A_t K_t^{1-\varphi} Q_t^{\varphi-\rho} \Theta_t H_t^{\rho-1} && (6)
\end{aligned}$$

where d is the depreciation rate of physical capital; r_t is the interest rate; and w_t^L, w_t^H and w_t^E are the marginal productivity associated with raw labor, education, and experience, respectively.

[6] At each date, the composite good is taken as the numeraire. The spot price is thus normalized to one.

A.3 Preferences

Based on De la Croix & Docquier (2007), we use a time-separable logarithmic utility function:

$$E(U^S_{X,t}) = \sum_{j=0}^{7} \Delta_{j,t+j} \ln(c^S_{X,j,t+j}) \tag{7}$$

where $c^S_{X,j,t+j}$ is the consumption of generation t at age j of a consumer of skill S and origin X. The term $\Delta_{j,t+j} = \prod_{s=1}^{j} \beta_{s,t}$ $(j = 1, ..., 7)$ is the cumulative probability of being alive at age j (evaluated relative to age 0) and such that $\Delta_{0,t+0} = 1$.

The budget constraint requires equality between the expected value of expenditures and revenues. For a native, this budget constraint is written as follows:

$$\begin{aligned} & \sum_{j=0}^{7} R_{j,t+j}\Delta_{j,t+j} \left[c^S_{N,j,t+j}(1+\tau^c_{t+j}) - T^S_{N,j,t+j}\right] \\ = \; & \left[\omega^L_{j,t+j} + \omega^E_{j,t+j} e^S_{N,j,t+j} + \omega^H_{j,t+j} h^S_{N,j,t+j}\right] \ell^S_{N,j,t+j} \end{aligned} \tag{8}$$

where τ^c_{t+j} is the tax rate on consumption in period $t+j$; $T^S_{X,j,t+j}$ denotes the amount of social transfers received at age j; $\ell^S_{X,j,t+j}$ measures labor supply at age j; $e^S_{N,j,t+j}$ and $h^S_{N,j,t+j}$ are education and experience stock at period $t+j$; $\omega^L_{j,t+j}$, $\omega^H_{j,t+j}$ et $\omega^E_{j,t+j}$ represent contingent net wages after taxes related to raw labor, education, and experience, respectively. With r_t, the interest rate between dates t and $t+1$, the discount factor applied to income and expenditures is given by

$$R_{j,t+j} \equiv \prod_{s=t+1}^{t+j} (1 + r_s(1-\tau^k_s))^{-1}$$

with the convention $R_{0,t} = 1$.

The implicit asset holdings $a^S_{X,j,t+j}$ is simply given by the difference between income and the consumption of the individual.

A.4 Educational decisions

Natives choose their level of education or, equivalently, the duration of their studies. The exogenous variable, $0 \leq \overline{u}_S \leq 1$ (as $\overline{u}_L < \overline{u}_M < \overline{u}_H$), measures the proportion of time that a native with a level of education S must devote to his/her education between the ages of 15 and 24. The proportion of people terminating their studies before their baccalaureate (π^L_t) is exogenous. For individuals who have reached an intermediate education level, the choice of the number of years of study is performed by comparing the gains and costs of a longer education. The monetary gain is measured by expected lifetime labor income, $E(Z^S_t)$, derived from the budget constraint [8]:

$$E(Z_t^S) \equiv \sum_{j=0}^{7} \left(\omega_{j,t+j}^L + \omega_{j,t+j}^E e_{X,j,t+j}^S + \omega_{j,t+j}^H h_{X,j,t+j}^S\right) \ell_{X,j,t+j}^S$$

The effort required for graduation is assumed to be proportional to the opportunity cost of education, $\lambda \omega_{0,t}^L \overline{u}_S (1 - v_t)$, where v_t denotes the rate of subsidy on the cost of education and λ is a scale variable determining the ability to educate. This ability, λ, is distributed uniformly over $\left[\underline{\lambda}, \overline{\lambda}\right]$.

The following condition defines the range of λ over which tertiary education dominates secondary education:

$$\lambda < \lambda_t^c \equiv \frac{E(Z_t^H) - E(Z_t^M)}{\omega_{0,t}^L \left[\overline{u}_H - \overline{u}_M\right] \left[1 - v_t\right]} \tag{9}$$

where λ_t^c is the critical level of ability below which tertiary education dominates secondary education in the cohort t.

Therefore, the proportions of agents opting for primary, secondary, and tertiary education are given by

$$\begin{aligned}
\pi_t^L &= \overline{\pi}_t^L \\
\pi_t^M &= (1 - \overline{\pi}_t^L) \frac{\overline{\lambda} - \lambda_t^c}{\overline{\lambda} - \underline{\lambda}} + \varepsilon_t \\
\pi_t^H &= (1 - \overline{\pi}_t^L) \frac{\lambda_t^c - \underline{\lambda}}{\overline{\lambda} - \underline{\lambda}} - \varepsilon_t
\end{aligned}$$

where $\overline{\pi}_t^L$ is the exogenous share of young unskilled workers and ε_t denotes a iid. stochastic process.

A.5 Wage and unemployment

We adopt a WS-PS approach to determine the levels of real wages and equilibrium unemployment at the aggregate level. We assume that wage negotiations between firms and labor unions lead to a real wage determined by applying a mark-up. The union representing the interests of unskilled workers is bringing claims about the level of base wage (w_t^L), while the union representing the skilled workers negotiates the part of the wages associated with education level w_t^H[7]. Thus, we have

$$\begin{aligned}
\log(w_t^L) &= \frac{1}{2} \log(w_t^L) + \frac{1}{2}(a_u \bar{\Phi}_t^L + \log(A_t) + \Lambda_t^L) \\
\log(w_t^H) &= \frac{1}{2} \log(w_t^H) + \frac{1}{2}(a_u \bar{\Phi}_t^{MH} + \log(A_t) + \Lambda_t^H)
\end{aligned}$$

[7]Therefore, the negotiations of a union, for example those representing the interests of unskilled workers, will also slightly influenced, by a second-order effect, the level of wages and unemployment of skilled workers.

where $\bar{\Phi}_t^L$ and $\bar{\Phi}_t^{MH}$ represent the average unemployment rate associated with unskilled workers and skilled workers. $\Phi_{X,j,t}^S$ denote unemployment rates by age, origin, and education level coming from employment surveys and $aj\_cho_t^L$ and $aj\_cho_t^{MH}$ are, respectively, uniform distributions variables to ensure that the average rate of unemployment of the unskilled workers ($\bar{\Phi}_t^L$) and skilled workers ($\bar{\Phi}_t^{MH}$) resulting from the intersection of WS and PS curves is equal to the weighted average unemployment rate for the two workforce groups.

Λ_t^L and Λ_t^H are adjustment variables, calibrated during the transition phase, so as to reproduce the historical rate of unemployment (also from employment surveys) and to ensure convergence in 2030 of the actual rate of unemployment to a long term unemployment rate 5.2% for unskilled workers and 3.8% for skilled workers. These figures correspond, given the population structure, to an average unemployment rate of 4.5% in 2030, compatible with the target hypothesis of the central scenario of the Conseil d'Orientation des Retraites (2012).

A.6 Labor supply, education, and experience

The time invested in education determines pattern of labor supply, education, and experience. The vector of raw labor supply for an agent of the generation t is written as

$$\ell_{X,t}^S = (q_t(1-\overline{u}_S),\ q_{t+1},\ q_{t+2},\ q_{t+3},\ q_{t+4}(1-\alpha_{t+4}),\ 0,\ 0,\ 0) \tag{10}$$

where q_t denotes the exogenous rate of activity in t and α_{t+4} represents the time spent in retirement (exogenous) during the fifth period of life (between ages 55 and 64).

As in Wasmer (2001b), we assume that the experience of an individual, $e_{X,t}^S$, is an aggregate of his/her past employment experiences such that

$$\begin{aligned} e_{X,t}^S \quad = \quad & (0,\ (1-\overline{u}_S)q_t\theta_e^1,\ (1-\overline{u}_S)q_t\theta_e^2 + q_{t+1}\theta_e^1, \\ & (1-\overline{u}_S)q_t\theta_e^3 + q_{t+1}\theta_e^2 + q_{t+2}\theta_e^1, \\ & (1-\overline{u}_S)q_t\theta_e^4 + q_{t+1}\theta_e^3 + q_{t+2}\theta_e^2 + q_{t+3}\theta_e^1,\ 0,\ 0,\ 0) \end{aligned} \tag{11}$$

where $\theta_e^j \in (0,1)$ represents 1 minus the depreciation rate of experience over time.

Educational human capital, $h_{X,t}^S$, transforms the investment during the first period of life in units of effective labor as a function with decreasing returns. This vector is written as

$$h_{X,t}^S = \left(0,\ \epsilon\overline{u}_S^{\psi},\ \epsilon\overline{u}_S^{\psi},\ \epsilon\overline{u}_S^{\psi},\ \epsilon\overline{u}_S^{\psi},\ 0,\ 0,\ 0\right) \tag{12}$$

where $\epsilon > 0$ and $\psi \in (0,1)$ characterize the production function of human capital.

We disregard assimilation issues and consider that experience and education accumulated abroad are equivalent to experience and education accumulated in the domestic economy. The aggregate quantities of raw labor (L_t), experience (E_t), and education (H_t) are given by

$$L_t = \sum_{j=0}^{7} \sum_{X=N,M} \sum_{S=L,M,H} P^S_{X,j,t} \ell^S_{X,j,t} \tag{13}$$

$$E_t = \sum_{j=0}^{7} \sum_{X=N,M} \sum_{S=L,M,H} P^S_{X,j,t} \ell^S_{X,j,t} e^S_{X,j,t} \tag{14}$$

$$H_t = \sum_{j=0}^{7} \sum_{X=N,M} \sum_{S=L,M,H} P^S_{X,j,t} \ell^S_{X,j,t} h^S_{X,j,t} \tag{15}$$

A.7 The public sector

The vector of public transfers, $\overline{T}^S_{X,t}$, consists of pensions, health costs, unemployment benefits, housing costs, family allowances, and social assistance spendings. $\gamma^S_{risk,X,j} g^{risk}_t$ represents the total age-related transfers made by the government to agents of age j, level of education S, and origin X for retirement (ret), health (san), unemployment (cho), housing (log), family (fam), and social assistance (rmi). The variable $\gamma^S_{risque,X,j}$ describes the profile of social aid and g^{risque}_t is a scale variable capturing the generosity of welfare programs.

$\gamma^S_{ret,X,j,t+j}$, measures pension benefits allocated to each full-time retiree from generation t in period $t+j$ ($j = 4$ to 7). Following current legislation, we assume that the pension is proportional to the average wage during the last twenty years of work[8] such that

$$\gamma^S_{ret,X,j,t+j} = \eta_{t+4} \eta_X \frac{1}{3} \sum_{k=2}^{4} \left[\omega^L_{k,t+k} + \omega^E_{k,t+k} e^S_{X,k,t+k} + \omega^H_{k,t+k} h^S_{X,k,t+k} \right] \qquad (j = 4, ..., 7)$$

where η_{t+4} denotes the replacement rate capturing the generosity of the pension system and η_M is a parameter capturing the relative pension of an immigrant compared to that of a native with the same characteristics ($\eta_N = 1$)[9].

The evolution of health expenditures is based on the size and structure of the population (captured by the profile $\gamma^S_{san,X,t}$) and the growth rate of the GDP. According to estimates by Mahieu (2000) and Azizi & Pereira (2005), we assume a price elasticity of health expenditures equal to one. Thus, an increase of 1% of the GDP, assuming all other things being equal, implies a 1% increase in health spendings. This does not mean that health expenditures are evolving at the same rate as the GDP. Other factors such as the changing age and skills structure of the French population also influence health expenditures.

Unemployment expenditures are derived directly from the application of unemployment rates by age, skill, and origin ($\Phi^S_{X,j,t} aj\_cho^S_t$) to individual profiles of unemployment benefits ($\gamma^S_{cho,X,t}$). All other social expenditures (housing, family, and social assistance) are modeled as a function of age, skills, and origin profiles and are adjusted uniformly to replicate the macroeconomic aggregates.

[8] In fact, this is the average annual wage of the 25 best years of careers.

[9] This parameter is necessary to take into account non linearity between pension and wage arising for example from the existence of penalty applied in case of earlier suspension of activity.

The government budget constraint can be written as follows:

$$(\tau_t^{eq} + \cot_t + csg_t)(w_t^L L_t + w_t^E E_t + w_t^H H_t) + \tau_t^c C_t + (\tau_t^{eq} + \tau_t^k + csg_t) r_t K_t + D_{t+1} \\ = v_t q_t \overline{u}_S \omega_{0,t}^L + \sum_j \sum_X \sum_S P_{X,j,t}^S \overline{T}_{X,j,t}^S + \vartheta_t Y_t + (1 + r_t) D_t \quad (16)$$

where D_t represents the public debt at the beginning of period t, τ_t^c is the tax rate on consumer spending, τ_t^k the tax rate on capital income, v_t is the rate of subsidy on the cost of education and ϑ_t is the share of government consumption (non-individualized) in GDP. Several fiscal rules can be used to balance the budget constraint (adjusted by taxes, expenditures, and the public debt). We assume that the path of debt/GDP ratio is given and the apparent tax (τ_t^{eq}) adjusts to balance the budget.

For each type of transfers, there is a special fund that is financed autonomously. These funds include a retirement fund, a fund for health expenditures, a fund for unemployment, a fund for family benefits and housing, and a fund for social assistance expenses. The last one is directly funded from the state budget and, therefore, does not receive any specific funding.

All other funds receive funding based on three sources: (i) social contributions (based on wages), (ii) earmarked taxes (mainly constituted by the *csg* and based on wages and capital income), and (iii) public contributions.

$$Solde_t^{risk} = T_t^{risk} - (\cot_t^{risk} + csg_t^{risk})(w_t^L L_t + w_t^E E_t + w_t^H H_t) - csg_t^{risk} r_t K_t \\ - cpub_t^{risk} \cot_t^{risk} (w_t^L L_t + w_t^E E_t + w_t^H H_t)$$

where $\cot_t^{risque}$ and csg_t^{risque} denote the rates of social contributions and taxes earmarked for each of the social risks, respectively. $cpub_t^{risque}$ represents the public contribution for each of the funds, expressed here as a proportion of social contributions. We do not impose that each social aid fund is balanced. $Solde_t^{risque}$ moves freely given the demographic and economic changes (but the public debt in the GDP is fixed; the apparent tax (τ_t^{eq}) adjusts to balance the inter-temporal budget constraints of the government).

B Robustness to the elasticity of substitution

The parameter ρ determines the magnitude of wage responses (the intensity of the relation between changes in factor proportions and changes in wages). Table 10 and 11 give the economic consequences of immigration in alternative models. The model behind Table 10 is calibrated with a low elasticity of substitution ($\rho = 0.5$ and $1/(1 - rho) = 2$. The model behind Table 11 is calibrated with a high elasticity of substitution ($\rho = 0.9$ and $1/(1 - rho) = 10$. The conclusion are similar to the baseline simulations.

- Insert Table 9 -

- Insert Table 10 -

C Alternative immigration scenarios in a partial equilibrium model

Immigrants induce many effects through the capital market, the markets for high-skill and low-skill labor and through public finance. This direct effects can be reinforced or offset by adjustments of wages (w_t^L, w_t^H and w_t^E), interest rate (r_t) and the equilibrium taxes (τ_t^{eq}). By "exogenizing" some prices and tax rates, we can estimate the importance of this macroeconomic feedback effects. Specifically, we simply assume here for each alternative migration scenarios that wages, the interest rate and the equilibrium tax retain their values of the baseline scenario. The findings of table 11 are very close to that arising from the use of our general equilibrium model. However, the effects of immigration tend to be accentuated in this partial equilibrium context, illustrating the need for a dynamic general equilibrium model to assess the global impact of immigration.

- Insert Table 11 -