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AGING, HUMAN CAPITAL, AND PRODUCTIVITY IN FRANCE: A GENERATIONAL ACCOUNTING PERSPECTIVE

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The aim of this paper is to highlight the potential productivity gains resulting from improvements in the (i) educational attainment and (ii) health status of the working-age population. For that purpose, we develop a Generational Accounting Model applied to the French economy. Using the conventional methodology of generational accounting, we first estimate the adjustments that will be necessary to ensure the sustainability of French fiscal policy in the long term under the assumption that individual taxes and transfers grow at the same rate as labor productivity. However, this assumption does not account for the explicit determinants of individual productivity. Therefore, we then explain how productivity growth is partly due to the French population's skill level and its health level, which is approximated by the survival rate of adults. We estimate that the increased educational attainment and improved adult survival rate in France generate potentially important productivity gains that could significantly challenge the weight of the burden induced by aging. Therefore, we estimate that this change could reduce the tax burden bequeathed to future generations by 79 percent. Our results are robust to the main assumptions.

JEL Codes: E62, H51, I10

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1. INTRODUCTION

The French population is engaged in an aging process that, far from being specific to France, affects virtually all populations worldwide. Although the French population has aged considerably over the past 35 years—the median age increased from 31.7 to 40 years—the mass retirement of the baby boomers is considerably amplifying the effects of the aging process. According to INSEE[1] (Blanpain and Chardon, 2010), the total French population should increase by approximately 20 percent between 2007 and 2060, although the French labor force is expected to remain relatively stable. During the same period, the share of the population aged 65 and over should nearly double. These demographic evolutions would induce a significant increase in the old-age dependency ratio—that is, the ratio of the population aged 65 and over to the population aged 15–64

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[1]The National Institute of Statistics and Economic Studies.

years—in the coming decades. Having been approximately 25 percent in 2007, this ratio could be as high as 47 percent in 2060.

The impact of these developments on public finances is a source of concern.[2] Based on current policies, public spending directly related to age could increase by approximately 3.1 percentage points of gross domestic product (GDP) according to the European Commission (2012). Most of this increase would come from spending on pensions (+0.5 point), health (+1.4 point), and long-term care (+2.1 points). Potential savings in expenditures targeting younger segments of the population (spending on education and unemployment in particular) would be very small (–0.4 for the former and −0.6 for the latter). Unfortunately, the slow growth of the French working-age population will not be able to absorb this increase in social spending. Therefore, the implicit public debt—that is, the present value of future deficits arising from population aging due to the rising costs of pensions, healthcare, and other age-related government expenditures—will substantially exceed explicit public debt.[3]

The use of the implicit public debt is called for because of the increasing difficulty of using the budget deficit as a good indicator of economic policy. Although it is widely used, the deficit exhibits the double disadvantage of being easily manipulated and, especially, static, thereby encouraging short-term policies. Use of the deficit would account for some receipts without integrating their counterparts in terms of future commitments. To incorporate long-term public commitments, Auerbach *et al*. (1991) developed generational accounting (GA) as an alternative to the budget deficit to assess the sustainability of fiscal policy in the long term. This approach builds on an intertemporal treatment of the government budget constraint: at any date, the present value of government purchases must be covered by the current net public wealth, the present value of the net taxes that will be paid by future generations over their entire lives. This technique makes it possible to evaluate, for the base year, the actual value of the net payments that current generations (i.e. those of which one or more members are still alive today) will pay to the state until the end of their lives. Based on the state's long-term budget constraint, the technique then compares the net burden carried by those born in the base year (the only generation to be followed across its entire lifespan) with the net burden to be carried by the generations to come (those born after the base year).

Using balanced growth assumptions, the classical methodology of GA defines the generationally balanced growth policy as a situation in which individual taxes and transfers increase at the same rate as labor productivity. However, existing GA exercises rely on very simple assumptions regarding the changes in labor productivity across generations. These changes are usually related to exogenous growth rates that have no explicit link to the human capital level held by each generation. However, the role of human capital in productivity is now well

[2]It should be noted here that we will only focus on the fiscal impact of aging. Thus, the non-monetary costs of aging are outside the scope of our study.

[3]The implicit public debt could range between 253 percent of GDP (Bovenberg and Van Ewijk, 2011) and 295 percent (IMF, 2012).

established (Mankiw *et al*., 1992). Not accounting for increases in human capital inevitably leads to an overestimation of the negative effects of aging on productivity and the public budget (Chojnicki and Docquier, 2007). The purpose of this paper is to revisit the standard GA methodology by introducing skill heterogeneity and productivity gains induced by the continuous increase in French life expectancy.

The concept of human capital, which was first highlighted by Schultz (1961) and Becker (1964), is the productive capacity acquired through the individual accumulation of general and specific knowledge and skills. It primarily consists of the education and health of workers. Increased educational attainment in successive cohorts affects the growth rate of labor productivity and influences the average age profile of taxpayers and recipients of transfers over time. Indeed, *ceteris paribus*, a higher educational level implies higher labor productivity, higher labor income and, at least, higher net tax payments. This is why the age profile of net taxes is highly dependent on educational attainment. Thus, by disaggregating the generational account of each generation by schooling level, Chojnicki and Docquier (2007) manage to highlight the positive effects of the first component of human capital, namely, education.

Health is the second component of human capital that positively affects labor productivity. Nelson and Phelps (1966) and Grossman (1972) were the first to demonstrate theoretically how better health improves labor efficiency and, consequently, labor productivity. Subsequent contributions by Bloom and Canning (2005), Weil (2007), Aghion *et al*. (2012), Barro (2013), and O'Mahony and Samek (2016) empirically validate these theoretical findings. In addition, regarding the effects of health on productivity in the long term, Ashraf *et al*. (2008) undertake quantitative simulations to assess the potential productivity gains generated by future health improvements. They estimate the effects of exogenous health improvements on output per capita in developing countries and report that the effects are slightly positive.

In this paper, we demonstrate that it is crucial to include workers' skill heterogeneity and health status when evaluating fiscal sustainability for three main reasons. First, the age profile of taxes and transfers is highly dependent on educational attainment. According to our estimates, the present value of taxes paid by an individual over his or her entire life amounts to €91,126 for low-skill, €136,958 for medium-skill, and €210,392 for high-skill workers. Second, the skill composition of the population has changed dramatically over time and is likely to change further in the future. For example, in 2008, 72 percent of the 80-year-olds in France had educational attainment below a baccalaureate[4] level, 13 percent had educational attainment between the baccalaureate level and a university undergraduate degree, and only 15 percent had a higher qualification. For the cohort aged 30, these figures were 35 percent, 24 percent, and 41 percent. Even if one assumes stability in the level of education of future young cohorts, the average education level of the population will continue to grow due to the gradual rise of young and educated people in the age pyramid. Third, if the increase in life expectancy is likely to substantially affect the financing of social protection

[4]The baccalaureate is a French academic qualification, which is usually obtained at the end of high school.

systems, these gains will also affect the working-age population and, potentially, positively affect worker productivity. For example, Bloom and Canning (2005) demonstrate that a 1-percentage-point increase in adult survival rates translates into a 2.8 percent increase in labor productivity. This is why we regard improved health as a determinant of the evolution of the growth of labor productivity in this paper.

The remainder of this paper is organized as follows. Section 2 provides the mathematical tools for GA with heterogeneous skill and health status. Section 3 discusses data issues and the calibration of net tax profiles by age and education. Section 4 presents the results of the conventional GA methodology (Auerbach *et al.*, 1991) with a single representative agent within each generation and where the labor productivity growth rate is considered exogenous. This conventional methodology yields our baseline scenario. We find that aging could generate an intertemporal public liability (IPL) of €2,260 billion (129 percent of 2010 GDP). The French government should increase all taxes by 13.5 percent or decrease all benefits by 14.5 percent to ensure the sustainability of French fiscal policy in the long term. Section 5 considers methodological issues affecting GA with skill heterogeneity and health status. First, compared with the baseline, we show that the total burden left for future generations is reduced by 62 percent when accounting for the future change in the skill structure of the French population. Second, we observe that the productivity gains generated by improving the health of the French population could reduce IPLs by 16 percent relative to the baseline. Furthermore, we find that the simultaneous improvement of the skill structure and the health status of the French population should generate productivity gains which can reduce IPLs by 79 percent relative to the baseline.

A sensitivity analysis is presented in Section 6. Our results are quite robust to discounting assumptions, skill premium forecasts, the educational level of future cohorts, and the elasticity of health with respect to productivity. Section 7 summarizes and concludes.

2. The GA Model with Human Capital

2.1. *Basic Features*

Generational accounting (GA) was first introduced by Auerbach *et al.* (1991) and is a meaningful way to evaluate the sustainability of a fiscal policy. The GA method relies on the notion of an intertemporal budget constraint that requires that all public expenditures must be financed by taxes. For the base year, this can be expressed as follows:

$$PVL_t + PVF_t = PVG_t - W_t. \tag{1}$$

According to equation (1), the French Government Budget is balanced in the long term when the present value of government purchases, PVG_t, less public net wealth, W_t, equals the sum of the present value of net tax payments by living generations over the rest of their lives, PVL_t, and the present value of net tax payments by future generations over the rest of their lives, PVF_t. W_t constitutes the only directly observable element. Traditionally, it is considered equal to the opposite of the national debt, leaving aside the government's wealth, particularly government assets.

The present value of government purchases, PVG_t, is the discounted sum of public expenditures:

(2) $$PVG_t = \sum_{s=t}^{\infty} \frac{G_s}{(1+i)^{s-t}},$$

where G_s measures public consumption that is not age specific in year s and i is the interest rate. Total public expenditures, G_s, is assumed to evolve under the double influence of population growth and productivity growth, which is equivalent to requiring expenditures to evolve according to productivity:

(3) $$\frac{G_s}{p_s} = (1+\gamma)^{s-t} \frac{G_t}{p_t},$$

where γ is the rate of productivity growth and p_t is the total population size in year t.

2.2. *Introducing Skill Heterogeneity*

The present value of net tax payments by living generations can be obtained by summing the present value of the net taxes that these generations will pay to the government over the rest of their lives; that is, by summing the generational accounts of living cohorts. We distinguish three educational levels (L = low skills, M = medium skills, and H = high skills) and assume that each individual lives for a maximum of D years. The present value of payments by living generations, PVL_t, can be written as follows:

(4) $$PVL_t = \sum_{j=0}^{D} \left(n_{j,t}^{L} p_{j,t}^{L} + n_{j,t}^{M} p_{j,t}^{M} + n_{j,t}^{H} p_{j,t}^{H} \right),$$

where $p_{j,t}^{X}$ is the size of type X population ($X = L, M, H$) of age j at time t and $n_{j,t}^{X}$ measures the generational account of these agents.

The generational account sums the value of net taxes to be paid by each type of individual over the rest of his or her life:

(5) $$n_{j,t}^{X} = \frac{1}{p_{j,t}^{X}} \sum_{k=j}^{D} \frac{\theta_{k,t+k-j}^{X} p_{k,t+k-j}^{X}}{(1+i)^{k-j}}, \quad j = 0, \ldots, D, \quad X = L, M, H,$$

where $\theta_{k,t+k-j}^{X}$ is the net tax payment by an agent of type X and age k at time $t+k-j$. In practice, $p_{k,t+k-j}^{X}$ can be projected using demographic forecasts (including mortality and net immigration flows), data on schooling levels per age, and estimates of the educational attainment of young living generations after the completion of their education.

Assume that there exist q types of taxes and transfers in the economy with $q=1,\ldots,Q$, and let τ be a tax if $\tau>0$ and a transfer if $\tau<0$. Then, we have

$$\theta^{X}_{k,t+k-j}=\sum_{q=1}^{Q}\tau^{X,q}_{k,t+k-j},\quad X=L,M,H, \tag{6}$$

in which $\tau^{X,q}_{k,t+k-j}$ describes the tax (resp. transfer) profile for a tax (resp. transfer) of type q of an agent who belongs to cohort k at time $t+k-j$ and has skill type X.

2.3. *Health Status and Productivity*

Most existing GA models assumes time invariance of the age distribution of taxes and transfers except for the rate of technical progress:

$$\tau^{X,q}_{k,t+k-j+1}=(1+\gamma)\times\tau^{X,q}_{k,t+k-j},\quad X=L,M,H. \tag{7}$$

The mechanical application of a uniform growth rate means that economic growth does not change the age profiles of taxes and transfers, and that the fruits of growth are shared equally among the different cohorts. However, an increase in the average endowment of human capital per worker is potentially able to generate substantial fiscal gains. According to human capital theory, explicit and particularly important determinants of individual productivity are education and health.

By introducing skill heterogeneity in GA (Section 2.2), we are able to account for the effects of education on the evolution of labor productivity and, therefore, on the evolution of the present and future generational accounts. To be able to consider the second explicit determinant of individual productivity, we assume a simple theoretical framework in line with Aghion *et al.* (2012). In period $t+k-j$, workers with skill X produce Y^{X}_{t+k-j} due to the production technology $F(A_{t+k-j},H^{X}_{t+k-j})$ as follows:

$$F\left(A_{t+k-j},H^{X}_{t+k-j}\right)=A_{t+k-j}\left(H^{X}_{t+k-j}\right)^{\rho}. \tag{8}$$

The production of workers with skill X then depends on the total factor productivity, A_{t+k-j}, and the health of workers, H^{X}_{t+k-j}. Intuitively, a higher level of health makes labor more productive and therefore increases the amount of efficiency labor in the economy. Assuming that $F(A_{t+k-j},H^{X}_{t+k-j})$ is a Cobb–Douglas production function, ρ describes the rate of return of H^{X}_{t+k-j} in equation (8). Let γ^{X}_{t+k-j}, g^{A}_{t+k-j} and $g^{h,X}_{t+k-j}$ denote the growth rates of Y^{X}_{t+k-j}, A_{t+k-j} and H^{X}_{t+k-j}, respectively. Using a Solow growth decomposition (Solow, 1957), we obtain

$$\gamma^{X}_{t+k-j}=g^{A}_{t+k-j}+\left(\rho\times g^{h,X}_{t+k-j}\right). \tag{9}$$

According to equation (9), the rate of productivity growth for workers with skill X at $t+k-j$ is simply the sum of the rate of total factor productivity growth,

(g^{A}_{t+k-j}), and the health improvement of the worker of type X, ($g^{h,X}_{t+k-j}$), weighted by ρ. Inserting equation (9) into equation (7), we introduce an explicit link between individual productivity and worker health.

2.4. *An Assessment of the Sustainability of Fiscal Policy*

Adding equation (9) into our GA framework, we can then assess the financial sustainability of public policies. Given the present value of payments by living generations, PVL_t, the present value of government purchases, PVG_t, and the net public wealth, W_t, we can easily determine the present value of net contributions of future generations, PVF_t, as the residual of the intertemporal budget constraint (equation (1)). However, if this indicator can be read as a burden/surplus bequeathed to future generations, it appears difficult to imagine carrying forward the adjustment only for future generations (i.e. those born after the reference year). One way to proceed is to compute the hypothetical generational accounts of future cohorts under current fiscal policy. Using the same reasoning as in equations (4) and (5) above, we write:

$$PVF_t^{*}=\sum_{s=t+1}^{\infty}\sum_{j=0}^{\mathrm{Min}[s-t-1;D]}\frac{\theta^{L}_{j,s}p^{L}_{j,s}+\theta^{M}_{j,s}p^{M}_{j,s}+\theta^{H}_{j,s}p^{H}_{j,s}}{(1+i)^{s-t}}, \tag{10}$$

where PVF_t^{*} is the present value of net payments by future generations if current fiscal policy is unchanged. This hypothetical value can then be compared with the residual value, PVF_t, computed from equation (1):

- if $PVF_t^{*}=PVF_t$, the policy is sustainable and there is no need to make a fiscal adjustment;
- if $PVF_t^{*} > PVF_t$, the government budget is in surplus and benefits could be increased without increasing taxes; and
- if $PVF_t^{*} < PVF_t$, the current policy is not sustainable: this implies that current policy must be adjusted to restore sustainability.

As in Raffelhüschen (1999), the sustainability of fiscal policy can then be estimated using the concept of intertemporal public liabilities (the "Sustainability Gap" in Auerbach *et al*., 1991) to obtain a measure of generational imbalances arising from following current fiscal policy for an infinite horizon. This indicator, IPL, is the residual of the intertemporal budget constraint, if all generations, present and future, receive the same tax treatment:

$$IPL=PVG_t-W_t-PVL_t-PVF_t^{*}. \tag{11}$$

This indicator assesses the extent of reforms designed to restore balance ($IPL=0$). If the present policy is unsustainable, the obvious strategy is to adjust taxes and/or transfers at some future date. In this paper, we use an adjustment method that covers all members of all generations. If a gap has to be financed (to cover a deficit), we compute the proportional adjustment in all taxes (or all transfers) required to balance the budget.

Let us decompose the net taxes on all generations into two basic components, taxes and benefits: $\theta^X_{j,s}=\theta^X_{T,j,s}-\theta^X_{B,j,s}$. A time-invariant adjustment factor can be applied to each of these components (η_T for taxes and η_B for benefits) to restore sustainability. We then apply these proportional changes to both living generations (over the rest of their lifetimes) and future generations to balance the budget constraint. Our adjustment rule is summarized by the following set of equations:

$$PVL_t^{adj}=\sum_{j=0}^{D}\sum_{k=j}^{D}\sum_{X=L,M,H}\frac{\left[\theta^X_{T,k,t+k-j}(1+\eta_T)-\theta^X_{B,k,t+k-j}(1-\eta_B)\right]p^X_{k,t+k-j}}{(1+i)^{k-j}},$$

$$PVF_t^{adj}=\sum_{s=t+1}^{\infty}\sum_{j=0}^{\mathrm{Min}[s-t-1;D]}\sum_{X=L,M,H}\frac{\left[\theta^X_{T,j,s}(1+\eta_T)-\theta^X_{B,j,s}(1-\eta_B)\right]p^X_{j,s}}{(1+i)^{s-t}},$$

$$PVG_t=PVL_t^{adj}+PVF_t^{adj}+W_t.$$

There is a continuum of pairs (η_T,η_B) restoring the balance. Two specific pairs are usually considered, one with $\eta_T=0$ if the balance is achieved through cuts in transfers and one with $\eta_B=0$ if the balance is achieved through tax increases.

3. Data Issues and Assumptions

The collection of data is the preliminary stage of any longitudinal exercise.

3.1. *Population Forecast*

Our baseline scenario uses the intermediate population projection of INSEE provided by Blanpain and Chardon (2010). We retain the intermediate population projection for the period 2007–60:

- the life expectancy at birth rises from 77.2 and 84.2 years for men and women in 2007 to 86.0 and 91.1 years, respectively, in 2060;
- the fertility rate remains at 1.98 children per woman between 2007 and 2015 and decreases to 1.95 children per woman after this period;
- the net number of persons immigrating to France is equal to 100,000 per year until 2060, which corresponds to the average net annual migration flows observed since the mid-2000s.

This scenario includes a sharp increase in the old-age dependency ratio (i.e. the number of people aged 65+ as a percentage of the number of people aged 15–64). The ratio was 25.3 percent in 2007 and is expected to reach approximately 47 percent in 2060 (see Table 1).

GA requires population projections to a very distant horizon. This is necessary to evaluate the net payment from living generations until the end of their lives, the value of public expenditures, and the generational accounts of future generations indefinitely. The INSEE forecasts are thus extended until 2110, assuming that the mortality, fertility, and migration rates remain at their 2060

TABLE 1

The Evolution of the French Population between 2007 and 2060

	2007	2020	2060
Total population (in thousands)	61,795	65,962	73,558
Population aged 15–64 years (in thousands)	40,266	40,704	41,831
Population aged 65 years and over (in thousands)	10,208	13,453	19,643
Old-age dependency ratio (65+/15–64)	0.2535	0.3305	0.4696

Source: Blanpain and Chardon (2010).

levels. Nonetheless, GA attributes little weight to the net payment of generations to a fairly distant horizon due to discounting effects.

3.2. *Educational Attainment*

Three educational levels are distinguished: low-skill workers are those who have an education level below a baccalaureate (LS); medium-skill workers are formed by those who have completed at most two years of education above the baccalaureate level (MS), and high-skill workers are those who have completed more than two years of study above the baccalaureate level (HS). We use data on the skill composition of living French cohorts in 2008 taken from the French population census (INSEE, 2008) for the population aged 30 and over. We assume that the skill structure of future cohorts (i.e. those aged 30 after 2008) to be constant. Thus, the resulting projection can be considered relatively pessimistic.[5]

The evolution of the skill structure of the French population over time is described by Figure 1. In 2008, 42.8 percent of the population aged 30 had a high skill level, compared with 22.1 percent who had a medium skill level, and 35.1 percent who did not even have a baccalaureate. Among those aged 60, these shares were 19.7 percent, 13.5 percent, and 66.8 percent, respectively. The main changes in educational attainment (as measure by the share of each educational group in the total French population) occurred before 2008. However, even assuming that there is no more progress in education attainment for younger cohorts (those aged 30 after 2008), the skill structure of the population is nonetheless affected even in the future due to the rise of the younger cohorts, which have a high educational level, in the age structure of the population.

3.3. *Tax and Transfer Profiles by Age and Educational Attainment*

Estimating the age profiles of taxes and benefits for a reference year is the basis for any longitudinal calculation. We consider the six main branches of social security expenditures, corresponding to the different risks defined by social security accounting: (1) retirement, (2) health, (3) family, (4) unemployment, (5) housing, and (6) poverty/exclusion. To these social security expenditures, we add education expenses, which also correspond to a form of transfer to a well-defined age group. On the income side, we retain six categories of taxes: labor income taxes, capital income taxes, consumption taxes, local taxes, GSC (generalized social contribution)/NDRC (national debt

[5]We estimate simulations based on a more optimistic assumption in Section 5.2.

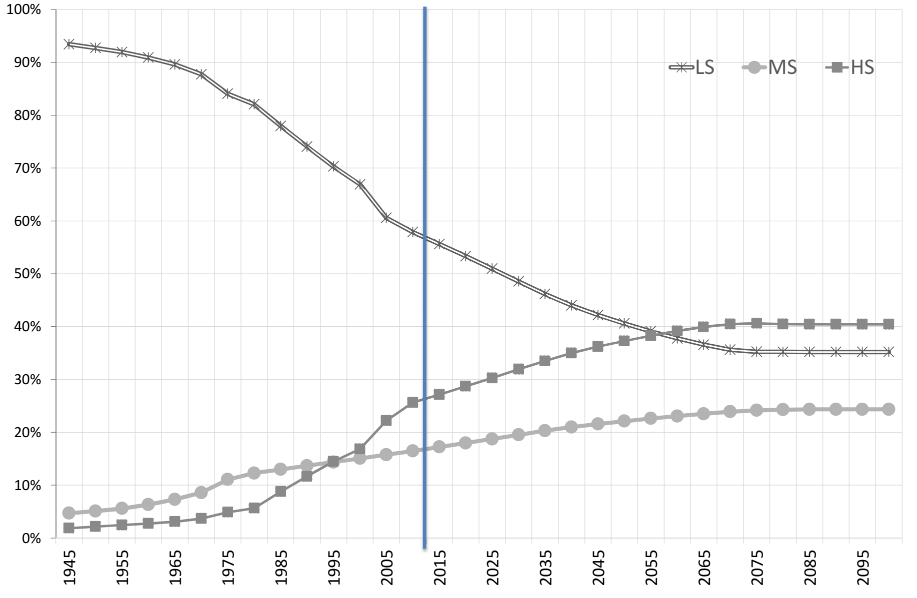

Figure 1. Population Shares by Educational Attainment (Percentage of the Total Population)

Source: INSEE (2008) and authors' calculations. [Colour figure can be viewed at wileyonlinelibrary.com]

repayment contribution), and social contributions. For the majority of profiles, we make use of the 2010–11 French household survey (INSEE, 2011a)[6] provided by the French institute for public statistics. Our sample consists of 30,416 individuals. To obtain sufficiently rich blocks of comparable sizes, we divide our database into five-year age slices. For each type of tax and transfer, the FHS2011 database thus allows us to determine the distribution by age and educational attainment of the various monetary flows considered. Some resources and expenditures are clearly individualized in the study, such as retirement, unemployment, and minimum income, but many others are only relevant at the household level and thus require certain assumptions to enable their individualization. Consequently, we attribute these monetary flows to the different members of the household proportionally to the revenues of each member of the household.[7] The majority of the taxes and transfers are reported directly in the FHS2011 database. The social contributions and the GSC–NDRC are calculated by reconstructing the gross revenues from activity and then by applying employee and employer social contribution rates as a function of the income level and the type of employment. The calculation of consumption taxes follows from the application of the different rates to the consumption expenses appearing in the FHS2011 database. With the exception of the GSC–NDRC, the taxes paid on capital income do not appear in the study, and hence we adopt the assumption that the profile of capital taxes is the same as that of capital incomes.

[6]FHS2011 thereafter.

[7]Our results are not sensitive to the way in which the resources are individualized within the household. On the other hand, this question becomes more important when generational accounts are disaggregated according to gender (for a discussion see, Raffelhüschen, 1999).

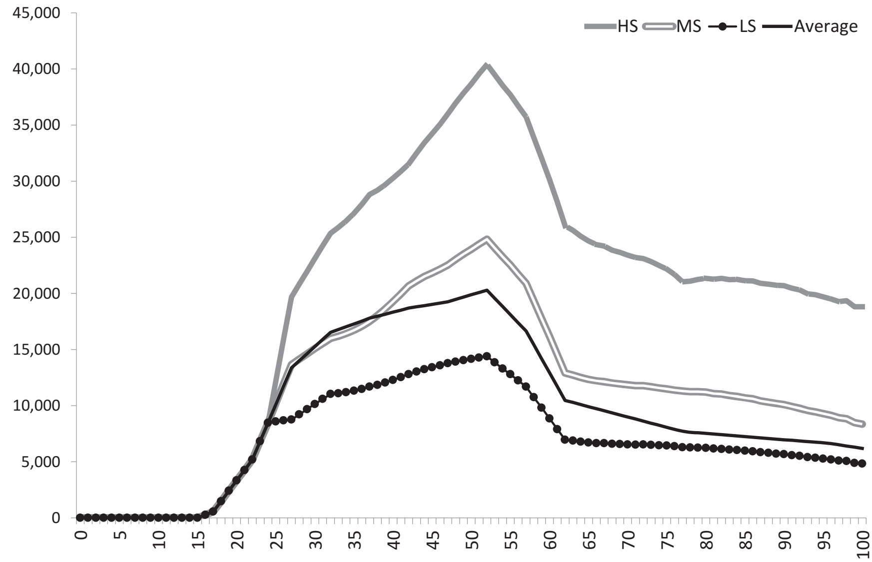

Figure 2. The Tax Profile by Age and Educational Attainment (in Euros)
Source: INSEE (2011a) and authors' calculations.

To obtain the distribution of healthcare expenditures by age and educational attainment, we use the 2010 healthcare study from the Institute for Research and Information in Health Economics (IRDES) provided by Dourgnon *et al*. (2012), which considers a sample of 15,973 individuals. As with the FHS2011 study, we consider five-year age slices and group total health expenditures to evaluate the total cost of healthcare.

For educational expenses, we evaluate the average cost by age by applying the enrollment rates by age, derived from the population census of 2008, to the average expenditure per graduate derived from the statistics of the national Ministry of Education.

Figures 2–4 give the decomposition by schooling level of total taxes, total benefits, and net taxes for each age group. The black bold lines represent the total taxes, benefits, and net taxes paid/received by a representative individual in each age cohort in 2010. The primary impact of educational attainment is on taxes: at age 50, the taxes paid by a high-skill individual are 2.6 times as great as those paid by a low-skill individual. Smaller differences are observed in benefit profiles. In terms of net taxes, low-skill agents are obviously the main beneficiaries of fiscal policy, while medium- and high-skill agents are net contributors. At age 50, the ratio of net taxes between a high- and a medium-skill individual is approximately 1.8 to 1. Hence, it is indisputable that changes in the educational structure will strongly affect the sustainability of current fiscal policy.

Each of the aggregates reconstituted from the profiles shown in Figures 2 and 3 differs from those given by the national accounts (Table 2). We therefore rescale them uniformly over these aggregates with the help of the national accounting report (INSEE, 2011b).

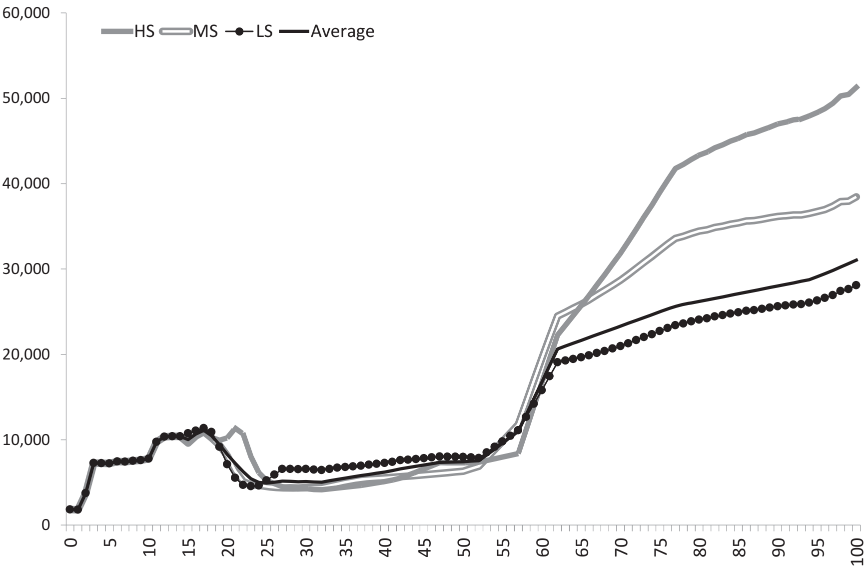

Figure 3. The Transfer Profile by Age and Educational Attainment (in Euros)
Source: INSEE (2011a) and authors' calculations.

Finally, the assumptions made for the construction of our reference scenario include a discount rate of 3 percent. In the baseline scenario based on the standard GA methodology, the growth rate of individual taxes and transfers[8] is set at 1.3 percent, corresponding to the medium variant of the official projections generated by the pension advisory council (Conseil d'Orientation des Retraites, 2012). Traditionally, only the financial wealth of the public administration, which totaled €1,109 billion in 2010, is retained.[9]

3.4. *Health Improvement and Labor Productivity Growth*

Following equation (9), the productivity growth rate is given by the sum of total productivity growth and the improvement in health weighted by its rate of return.

Measuring the Health Improvement

According to equation (9), we must estimate the annual health improvement experienced by the French population to evaluate the labor productivity for each skill and for each year. However, there is no consensus on an appropriate indicator that provides a good measure of health improvement at the macroeconomic level. On the one hand, authors such as Sachs and Warner (1997), Bloom and Williamson (1998), Bloom *et al.* (2004), Acemoglu and Johnson (2007), Cervellati and Sunde (2011), Aghion *et al.* (2012), and Barro (2013) assess the health improvement of a given population through its increase in life expectancy at birth.

[8]With the exception of pensions, which according to the law, keep pace with inflation.
[9]In 2010, the gross debt of the social security institutions accounted for 11 percent of total government debt.

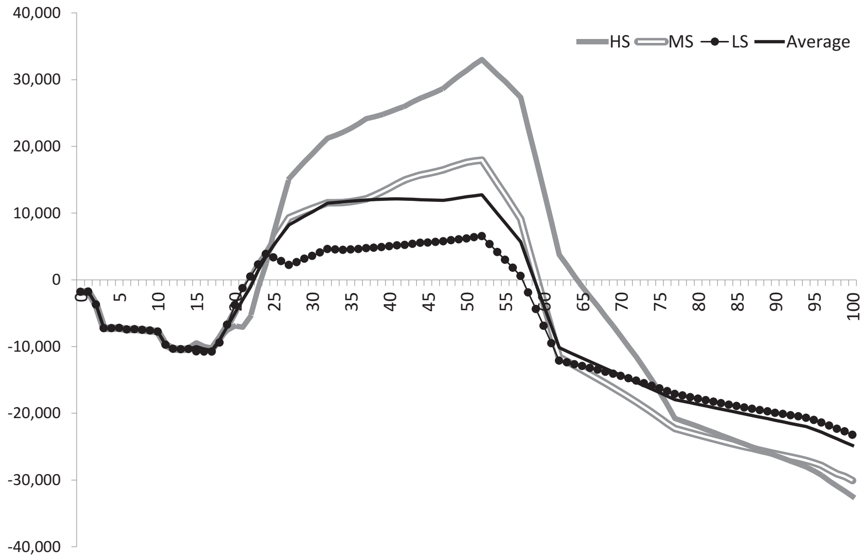

Figure 4. The Net Tax Profile by Age and Educational Attainment (in Euros)
Source: INSEE (2011a) and authors' calculations.

The increase in life expectancy at birth is retained because it is assumed implicitly that improved health allows for an extended life. On the other hand, authors such as Bhargava *et al*. (2001), Bloom and Canning (2005), Weil (2007), and Ashraf *et al*. (2008) measure the health improvement of a given population by the evolution of its average survival rate (ASR). The insight is that the ASR is a positive function of health improvement.

In this paper, we employ the survival rate rather than life expectancy as a health indicator. An increase in life expectancy primarily captures the increase in lifespan induced by the aging process that appears after one's working-age life.

TABLE 2
Public Taxes and Spending in 2010 (in Millions of Euros)

Taxes	Millions of Euros	% of GDP	Transfers	Millions of Euros	% of GDP
Labor income taxes	43,026	2.43	Pension	253,579	14.31
Capital income taxes	34,674	1.96	Housing	14,960	0.84
Excise taxes	157,535	8.89	RMI	13,206	0.74
Council taxes	42,603	2.40	Unemployment	35,024	1.98
GSC–NDRC	80,866	4.56	Family	50,327	2.84
Social contributions	330,376	18.64	Health	169,460	9.56
Other taxes	188,009	10.61	Education	124,085	7.00
			Other spendings	302,004	17.04
			Interest	40,137	2.26
Total	877,090	49.48	Total	1,002,782	56.57
			Deficit	125,692	−7.09

Sources: French national account, INSEE; French social security account, Drees.
Notes: GSC, generalized social contribution; NDRC, national debt repayment contribution; RMI, minimum income.

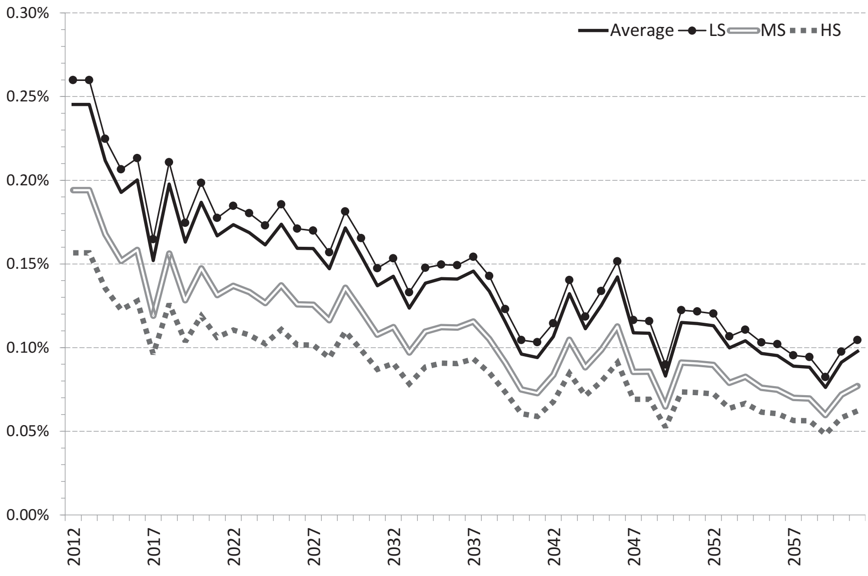

Figure 5. The Growth Rate of the Average Survival Rate for Each Year
Source: INSEE (2008) and authors' calculations.

Thus, if we assume that the life expectancy is a good health proxy, the increase in life expectancy primarily reflects the improvement in the health of the retired population. However, the aim of this paper is to highlight the productivity gains in the workforce from an improvement in health induced by the aging process.

Blanpain and Chardon (2010) assess data on the evolution of the survival rate for each generation in the French population for each age and for each year between 2007 and 2060. We disaggregate the survival rates by skill using the estimates of Mejer (2004). Beyond 2060, we assume that the survival rate for each skill and for each age remain at their 2060 levels. It is important to note that the data on survival rates are strictly the same as those used to undertake the population forecast. By using the INSEE data, we can approximate the health improvement among the population aged 15–64 years for each cohort and for each skill. The annual growth rate of the average survival rate (ASR) of the working-age population gives the numerical value of the variable $g^{h,X}_{t+k-j}$ in equation (9). The evolution of $g^{h,X}_{t+k-j}$ over time is then shown in Figure 5.

First, the growth rate of the ASR for each year and for each skill is relatively low. Between 2010 and 2060, the growth rate of the ASR is below 0.5 percent per year. In other words, the health improvement of the French workforce induced by the aging process is not very important over time. However, we will subsequently show that this small health improvement can nevertheless produce significant productivity gains (see Section 4.3). Second, we note that the growth rate of the ASR decreases each year. Thus by assuming that the ASR is a good health proxy, the INSEE forecasts show that the health improvement induced by the French population aging declines over time. Third, on average, the health improvement of the French workforce as a whole derives primarily from LS and MS health improvement.

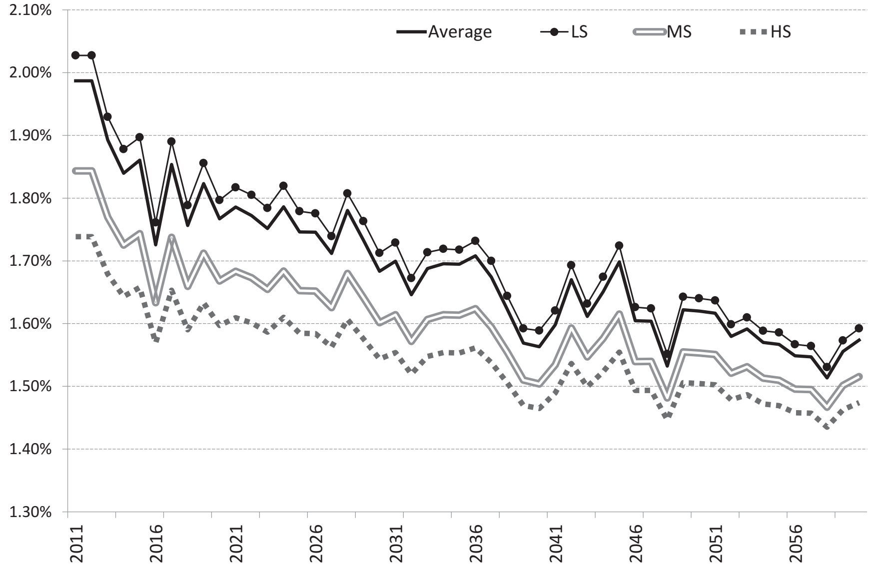

Figure 6. Labor Productivity Growth with Productivity Gains from Health
Source: INSEE (2008) and authors' calculations.

Estimating the Evolution of Productivity Growth

The impact of health on labor productivity is measured by the value of ρ. The estimation of this parameter is far beyond the scope of this study, and we prefer to use the results of Bloom and Canning (2005). Indeed, by assuming that the ASR reflects the health of the workforce, they estimate ρ using a panel of 21 OECD countries observed every five years from 1960 through 1995. They report that an increase in the ASR by 0.01 could increase productivity by 2.8 percent. The retained elasticity of Bloom and Canning (2005) corresponds to an intermediate value between the findings of Weil (2007) and Barro (2013). By using the same proxy for health as Bloom and Canning (2005), Weil (2007) finds that $\rho=0.0653$. By contrast, Barro (2013) uses life expectancy at birth to approximate the health of the population and finds that $\rho=0.014$. In Section 5, we will test the sensitivity of our results to these different values of ρ.

Finally, the value of the total factor productivity (*TFP*) growth rate is assumed to be constant over time and independent of skill level. In other words, $g^A_{t+k-j}=g^A$. To provide a numerical value for g^A, we refer to Cabannes *et al.* (2013). These authors estimate the evolution of *TFP* in France between 1979 and 2010 and obtain that $g^A=1.3$ percent during this period. We retain this value and assume that the average past trend in the evolution of *TFP* in France persists in the long term.

Figure 6 depicts the evolution of labor productivity for our GA exercise. Health enhancement generates significant productivity gains that vanish over time. On average, productivity growth decreases to 1.57 percent in 2060 and stabilizes at 1.3 percent after 2060. Thus, beyond 2060, the productivity growth of the French workforce reaches its long-term value and the economy evolves along a balanced growth path. After 2060, productivity growth is the same for each skill and for each cohort, and remains at 1.3 percent.

4. A Better Assessment of Human Capital Effects on Labor Productivity

For each scenario, we proceed as follows to obtain generational accounts for living and future generations. The use of assumptions regarding the time path of government purchases and individual amounts of taxes and transfers for living generations enables us to derive the present value of government purchases and payments made by living generations. It is also possible to compute the hypothetical generational accounts of future cohorts under the same fiscal policy as that used for living cohorts. Combining these amounts in the government's intertemporal budget constraint, we compute the fiscal adjustment required to balance the budget. This adjustment affects taxes and/or transfers from 2010 onwards. Hence, it affects the situation of both living and future generations. Depending on the type of adjustment we opt for, we compute the "adjusted" generational accounts of living and future generations that are sustainable with respect to the budget.

We present four different scenarios. In the first (Section 4.1), we use the traditional GA methodology. In the second (*scenario EA* in Section 4.2), we disaggregate generational accounts only by schooling level. The comparison of the first and second scenarios allows us to measure the fiscal gains induced by changes in the skill structure of the French population. In the third scenario (*scenario HI* in Section 4.3), we apply the revised GA model described in Section (2) and isolate the fiscal gains generated by improvements in health. Finally, our fourth scenario (*scenario EA + HI* in Section 4.4) combines the future change in the skill structure and the productivity gains from improved health.

4.1. *Baseline Results*

Our baseline results are obtained using the conventional GA methodology (Auerbach *et al*., 1991). The generational accounts of living generations in 2010 are summarized in the first part of Table 3. These accounts give the net payment (total taxes paid minus total transfers received) of each generation alive in 2010 until the end of their lives. We recover fairly standard results: these accounts increase in the first year of life and peak at approximately age 25. Then, they decrease due to the reduction in the time remaining in an individual's active working life and the lesser discounting of expenses tied to old age (retirement, healthcare, and disability). They become negative at approximately age 50, reach their minimum at approximately age 70, and then increase again due to the decrease in the time left to live.

To evaluate the sustainability of fiscal policy in France over the long term, we calculate the total of the intertemporal financial obligations, the IPL, which corresponds to the difference between the nominal value of the national debt for the year 2010 and the actualized value aggregated from the net payments of living and future generations (Table 4). This is determined by adding to the net debt

TABLE 3

GENERATIONAL ACCOUNTS OF LIVING GENERATIONS

	Present Value of Taxes	Present Value of Benefits	Generational Accounts
Baseline scenario			
0	136,160	−169,311	−33,152
20	316,066	−157,581	158,485
30	368,435	−174,487	193,948
40	326,851	−197,295	129,556
50	251,563	−227,915	23,648
60	146,206	−281,375	−135,169
70	97,261	−249,417	−152,156
100	6,261	−26,473	−20,212
GA with educational attainment (weighted average)			
0	150,518	−169,542	−19,024
20	350,205	−164,598	185,607
30	429,982	−181,813	248,169
40	373,254	−208,746	164,508
50	269,172	−238,824	30,348
60	159,301	−295,463	−136,162
70	100,956	−260,498	−159,543
100	6,238	−26,916	−20,678
Low skill			
0	91,126	−17,1041	−79,915
20	210,137	−165,436	44,700
30	234,784	−188,893	45,892
40	213,695	−196,872	16,823
50	166,032	−214,892	−48,860
60	97,720	−255,669	−157,949
70	70,947	−225,139	−154,193
100	4,544	−23,579	−19,034
Medium skill			
0	136,958	−163,037	−26,079
20	318,257	−151,014	167,242
30	379,073	−175,858	203,216
40	362,409	−209,835	152,575
50	294,725	−265,226	29,499
60	178,983	−348,901	−169,918
70	128,208	−324,091	−195,883
100	8,015	−33,861	−25,846
High skill			
0	210,392	−172,151	38,241
20	491,391	−172,043	319,348
30	617,990	−179,087	438,903
40	601,338	−224,750	376,588
50	517,772	−282,909	234,863
60	347,381	−389,350	−41,969
70	246,507	−403,625	−157,118
100	17,717	−46,476	−28,759

Source: Authors' calculations.
Note: Present value in 2010 euros.

observed in 2010 the sum of the generational accounts of present and future generations, multiplied by the respective sizes of the cohorts according to our population projections, as well as public consumption. In a case in which fiscal policy is not changed (such as the rights to retirement benefits that will have to be

TABLE 4

Intertemporal Budget Constraint Equilibrium: Baseline Scenario

Newborns' generational account	−33,152
Implicit debt (in % of 2010 GDP)	66
Explicit net debt in 2010 (in % of 2010 GDP)	63.6
IPL (in % of 2010 GDP)	129.6
Tax adjustment (%)	13.46
Adjusted newborns' generational account	−14,830
Transfer adjustment (%)	−14.55
Adjusted newborns' generational account	−8,512
Tax and transfer adjustment (%)	6.99
Adjusted newborns' generational account	−11,795

Source: Authors' calculations.

honored), this net intertemporal debt, based simultaneously on the actual debt and future revenues and obligations of public administrations, would be on the order of 130 percent of 2010 GDP. The current fiscal policy is thus not sustainable in the long term because the net current and future payments are negative and will further increase the current level of the national debt.

For a newborn in 2010, the prospective net payments over his or her life cycle are negative (on average, a newborn in 2010 will thus receive more over his or her life cycle than he contributes). Because the discounted value of the net payments of present and future generations is unable to cover the total public consumption and the current national debt, adjustments to the fiscal policy are clearly necessary. For that purpose, we use an adjustment method that concerns all members of all generations. In a first step, we compute the present value of payments by future generations under the current fiscal policy. Comparing this amount to the residual burden given by the budget constraint, we obtain the gap to be financed by all living and future generations. In a second step, we compute the proportional adjustment in all taxes (or in all transfers) required to balance the budget. Finally, given the "adjusted" fiscal policy, we derive the new generational accounts. Our adjustment calculations rely on the counterfactual assumption that all changes begin in 2010. Thus, a proportional increase in the tax rate by 13.5 percent or a decrease in all transfers by 14.6 percent for the generations alive in 2010, as well as for future generations, would make the budget viable over the long term. Such a policy would significantly increase the net contribution of a newborn in 2010 (to approximately €18,322 in the case of a tax adjustment and €21,357 in the case of a transfer adjustment).

4.2. *Generational Accounts and Educational Attainment*

The conventional GA methodology overstates the tax burden generated by aging because it does not account for the productivity gains from the change in the skill structure of the French population (Chojnicki and Docquier, 2007). Thus, we now compute generational accounts by explicitly accounting for changes in the skill structure of the French population as reported in Figure 1. The

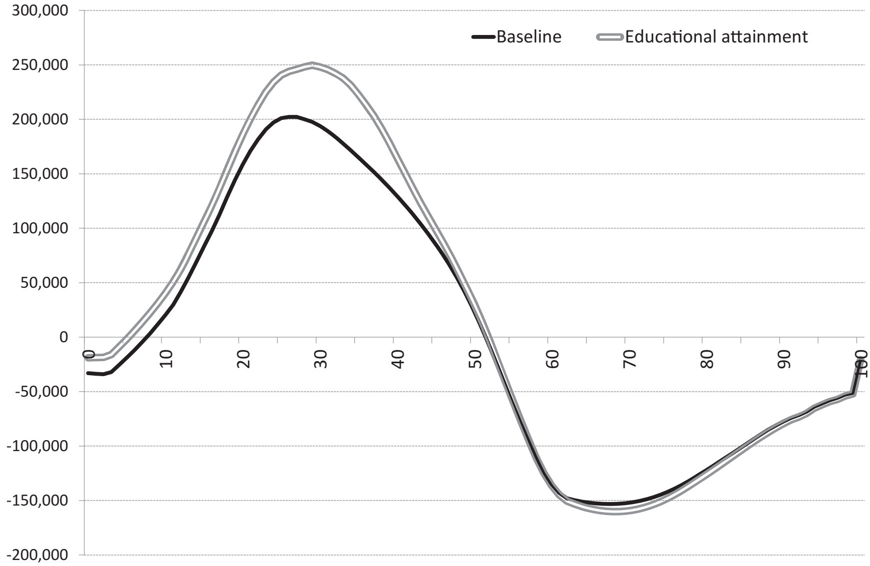

Figure 7. The Average Generational Account per Living Cohort: Baseline versus Educational Attainment (Present Value in 2010 Euros)

Source: Author's calculations.

generational accounts by skill level of living generations in 2010 are summarized in the second part of Table 3.

It is evident that generational accounts vary with respect to skill level. Thus, over their entire lifetime, unskilled and medium-skill agents have negative generational accounts and are expected to receive more in transfers than they pay in taxes to the government. Specifically, the average generational account of a low-skill newborn is three times less than that of a medium-skill newborn. Conversely, the generational account of high-skill individuals is positive. It is worth noting that generational accounts of low-skill agents are negative under 16 years of age and after 45, while this is true before age 7 and after 52 for the medium-skill and only after 58 for the high-skill agents.

Given the changes in the skill composition of these living cohorts, our average generational accounts per cohort are not identical to those given in our baseline scenario using the standard GA methodology (Table 3 and Figure 7). The differences are small for old cohorts but quite large for younger cohorts. If we extrapolate the future taxes and transfers of newborns on the basis of the present profile alone, the classical method underestimates newborns' average account by 74 percent (–€33,152 compared to –€19,024).

An examination of the sustainability of fiscal policy requires computation of the present value of payments by future generations under the current policy and the employment of some assumptions concerning forecasts of the educational structure of future generations. Here, we adopt the most consensual assumption of maintaining the level of education of future generations on the basis of those who left the school system in 2010. Despite the remarkable rise in educational attainment as a result of the spread of education among younger generations,

TABLE 5

Intertemporal Public Liabilities and Fiscal Adjustments in the Different Scenarios

	IPL (% of 2010 GDP)	Tax Change (%)	Transfer Change (%)	Tax and Transfer Change (%)
Baseline scenario	129.64	13.46	−14.55	6.99
Educational attainment (EA)	48.53	4.53	−5.28	2.44
Health improvement (HI)	108.22	10.35	−11.52	5.45
EA&HI	26.76	2.34	−2.79	1.27

Source: Authors' calculations.

maintaining the current policy for future generations generates a present value of payments lower than the total burden left by living generations. In other words, the current fiscal policy is still unsustainable: the tax burden bequeathed to future generations decreases by 62 percent relative to the baseline (Table 5).

Restoring the balance through tax adjustment induces an increase in all taxes by 4.5 percent (Table 6). The newborns' generational accounts then become –€75,792, –€19,881, and €47,762 for low-, medium-, and high-skill agents, respectively. It should be noted here that tax adjustment falls much more heavily on the skilled (MS and HS), while the unskilled would be relatively spared. Restoring the balance through transfer adjustment induces a cut in all transfers by 5.2 percent. The newborns' generational accounts then become –€70,880, –€17,466, and €47,335. These results contrast with the traditional method developed in the baseline scenario, which predicts that generational balance requires increasing all taxes by 13.5 percent or reducing all benefits by 14.6 percent. This demonstrates the huge potential impact of the rise in educational attainment in evaluating the long-run sustainability of fiscal policies.

4.3. *Generational Accounts and Health*

In addition to education, health is another important determinant of the evolution of individual productivity. As we explained in Section 3.4, we

TABLE 6

Generational Imbalance: Educational Attainment Scenario

	Present Value of Taxes	Present Value of Benefits	Generational Accounts
Newborns' generational account			
LS	91,126	−171,041	−79,915
MS	136,958	−163,037	−26,079
HS	210,392	−172,151	38,241
Restoring the balance through tax adjustment (+4.53%)			
LS	95,249	−171,041	−75,792
MS	143,156	−163,037	−19,881
HS	219,913	−172,151	47,762
Restoring the balance through transfer adjustment (–5.28%)			
LS	91,126	−162,006	−70,880
MS	136,958	−154,425	−17,466
HS	210,392	−163,057	47,335

Source: Authors' calculations.
Note: Present value in 2010 euros.

TABLE 7

Generational Imbalance: Health Improvement Scenario

Present Value of Taxes	Present Value of Benefits	Generational Accounts
Newborns		
157,415	– 182,226	– 24,811
Restoring the balance through tax adjustment (+10.35%)		
173,712	−182,226	−8,514
Restoring the balance through transfer adjustment (–11.52%)		
157,415	−161,234	−3,819

Source: Authors' calculations.
Note: Present value in 2010 euros.

assume that the average survival rate is a good proxy for the health of the working-age population. Here, we will simply introduce equation (9) in our GA model to include the effect of health improvement on individual productivity. In a first step, we do not consider skill heterogeneity to isolate only the effect on productivity due to improvements in the health status of the working-age population.

Does the introduction of the evolution of productivity due to the health status of the population fundamentally change the evaluation of our generational accounts? Table 7 gives the generational accounts of living generations and the required adjustments. Treating health status as a determinant of individual productivity increases the newborns' account: the difference from the baseline scenario amounts to €8,341. This number measures the average improvement in health for a newborn in 2010 (in present value at birth). Naturally, the changes relative to the baseline are more important for young individuals. Extrapolating the future taxes and transfers of newborns on the basis of an exogenous productivity growth rate, the classical GA method thus underestimates newborns' average account by approximately 33.5 percent. The effect on generational accounts is less pronounced here than when the gains from education are included, but is not negligible. In this scenario, the current fiscal policy is naturally still unsustainable and generates a long-run budgetary deficit (IPL) that is reduced by 16.5 percent relative to the baseline (Table 5). However, the necessary adjustments of taxes or transfers are not similar to those required in the baseline scenario. In this scenario, the government should increase all taxes by only 10.4 percent (+13.5 percent in the baseline scenario) or should cut all benefits by only 11.52 percent (–14.6 percent in the baseline scenario).

4.4. *Generational Accounts and Human Capital*

Finally, let us combine the effects of an increase in the population's education level with the improvement of its health on the evolution of individual productivity. This scenario goes beyond a simple linear combination of the two previous scenarios. Indeed, as changes in survival probabilities differ with respect to skill level, here the changes in individual productivity will vary according to

TABLE 8
Generational Imbalance: Educational Attainment and Health Improvement Scenarios

	Newborns' Generational Account	
	EA	EA&HI
LS	−79,915	−79,236
MS	−26,079	−18,616
HS	38,241	51,326
	Restoring the balance through tax adjustment (+4.53%)	**Restoring the balance through tax adjustment (+2.34%)**
LS	−75,792	−76,755
MS	−19,881	−15,021
HS	47,762	56,739
	Restoring the balance through transfer adjustment (–5.28%)	**Restoring the balance through transfer adjustment (–2.79%)**
LS	−70,880	−74,066
MS	−17,466	−13,807
HS	47,335	56,353

Source: Authors' calculations.
Note: Present value in 2010 euros.

our three skill levels.[10] As reported in Figure 6, the LS workers have higher labor productivity growth than the MS and HS workers between 2010 and 2060. For example, the productivity growth of LS, MS, and HS workers amounts to 2.03 percent, 1.84 percent, and 1.74 percent, respectively, in 2011.

The results in terms of the long-term imbalance (Table 5), measured by the intertemporal public liability (IPL), are less troubling than those resulting from the simple consideration of the impact of educational attainment on individual productivity presented in Section 4.2: the IPL is reduced by 21.7 points of 2010 GDP (26.8 percent vs. 48.5 percent) against 19.58 points without considering skill heterogeneity (108.2 percent vs. 129.6 percent). Thus, the required fiscal policy adjustments induce an increase in all taxes of approximately 2.3 percent (vs. 4.5 percent in the educational attainment scenario) and a cut in all transfers of approximately 2.8 percent (vs. 5.3 percent in the educational attainment scenario).

5. Sensitivity Analysis

In this section, we analyse the sensitivity of our calculations to alternative assumptions regarding the difference in net taxes across education groups (Section 5.1), about the educational attainment of future cohorts (Section 5.2), and about the discount rate and the rate of return of health on labor productivity (Section 5.3).

[10]Our strategy of combining the effects of education and health status as components of human capital is very simple. In this respect, there is a fairly wide literature on the relationship between health and education. See, for example, Cutler and Lleras-Muney (2010) or Clark and Royer (2013).

5.1. *Skill Premium Forecasts*

Our results show that if the structure of taxes and transfers is held constant, changes in the skill composition of the population will yield increases in future tax payments and decreases in future transfer payments. Are these fiscal gains robust to the increasing supply of skills? Are these results robust to possible changes in the structure of returns to skill? Most advances in educational attainment have occurred in recent decades. Over the past 20 years, skill-biased technical changes have increased the skill premium despite a remarkable rise in educational attainment. Indeed, according to the French labor force survey, the average wage gap between a high-skill and low-skill worker has increased from 1.25 in the early 1990s to 1.8 just 20 years later. Will this persist in future decades?

As Acemoglu (2002) argues, the rise in educational attainment could, alternatively, drive the skill premium upwards, because an increase in the supply of skills can incentivize firms to invest in skill-biased technologies. Nevertheless, it is also possible that educational increases will generate a slight compression in the wage distribution. A complete model of the labor market would be required to assess the impact of the supply of skills on relative wages. Such a task goes beyond our purely accounting framework. Here, we consider a simple scenario in which (i) the tax profile of medium-skill workers is held constant, (ii) the low-skill relative to medium-skill gap in the tax profile increases by 5 percent, and (iii) the high-skill relative to medium-skill gap in the tax profile decreases by 5 percent. Hence, the high-skill to low-skill gap decreases by 10 percent. The assumption of a larger change would be rather inconsistent with our assumption concerning the schooling decisions of future cohorts. These changes are introduced progressively and linearly. The total reduction in wage inequality is obtained in 2060.

The results are presented in Table 9. The low-skill newborns' generational account and the high-skill newborns' account do not change with variation in the

TABLE 9
The Sensitivity of GA and Budgetary Adjustments to Skill Structure

	EA&HI	Lower Skill premium & HI	Better Skill & HI
Newborns' generational account			
LS	−79,236	−79,236	−78,749
MS	−18,616	−18,616	−18,145
HS	51,326	51,326	51,820
Restoring the balance (%)			
Through tax change	2.34	3.06	−1.52
Through transfer change	−2.79	−3.63	1.89
Newborns' generational account after policy adjustment			
Taxes			
LS	−76,755	−71,905	−80,365
MS	−15,021	−13,905	−20,486
HS	56,739	48,937	48,295
Transfer			
LS	−74,066	−68,552	−82,242
MS	−13,807	−12,360	−21,392
HS	56,353	48,666	48,426

Source: Authors' calculations.

skill premium. In terms of generational imbalance, the deficit increases. Taxes need to be increased by 3.1 percent (instead of 2.34 percent in the scenario combining both an increase in the population's education level and the improvement of health on the evolution of individual productivity) or transfers have to be reduced by 3.6 percent (instead of 2.79 percent). These policy changes are still much smaller than those required when using the conventional GA methodology (see Section 3). We could thus conclude that our findings are quite robust to assumptions concerning skill premium forecasts.

5.2. *The Educational Level of Future Cohorts*

Let us now examine the sensitivity of our results to the assumptions concerning the educational attainment of young and future generations. Our benchmark educational attainment scenario is relatively pessimistic. It assumes the stability of the educational structure of the cohort aged 30 years in 2010 for all future generations. After 2010, we simply assume that the skill structure of future cohorts (aged 30 after 2010) will be stationary. For individuals who have just completed schooling in 2010, the percentages of low-, medium-, and high-skill workers are 35 percent, 22 percent, and 43 percent. Here, we simulate a more optimistic alternative forecast. The EU's Lisbon Strategy includes the objective of 50 percent of a generation having completed at least licensure. Thus, we adopt here a more optimistic assumption regarding future educational attainment: in the long run, we assume that the proportion of high-skill workers aged 30 will reach 50 percent in 2020, against 17.5 percent for low-skill workers and 32.5 percent for medium-skill workers.

Table 9 presents the results. Clearly, newborns' generational accounts are quite stable. In terms of generational balance, the higher-skill scenario has a substantial impact on the long-run-deficit and generates a fiscal surplus in the long term. Taxes could be reduced by 1.5 percent (vs. +2.3 percent under our conventional assumption regarding future educational attainment) or transfers could be increased by 1.9 percent (instead of −2.8 percent). Of course, achieving the better skill variant's educational attainment would likely require highly expansionary education policy. If the marginal cost of education increases, the discounted cost of such a policy could exceed the discounted gains. In some sense, the baseline scenario appears more reliable because it is based on current state commitments. Nevertheless, our sensitivity analysis demonstrates the crucial role of education policies in the debate on aging and public finance.

5.3. *Interest Rates and the Influence of Health on Productivity*

The generational accounts also depend on uncertain assumptions regarding the discount rate and the influence of health on individual productivity. As noted above, the reference case uses a real discount rate of 6 percent. The choice of the discount rates may be debatable. The choice of discount rate is crucial because it determines the relative weight given to future net payments relative to current ones (Diamond, 1996).

TABLE 10

THE SENSITIVITY OF THE EA&HI SCENARIO TO DISCOUNT RATE AND INFLUENCE OF HEALTH ON PRODUCTIVITY (ρ)

	Newborns' generational account		
	$i=0.05$	$i=0.06$ *(Baseline)*	$i=0.07$
	−13,490	−33,152	−44,813
		Tax change (baseline) (%)	
	10.99	13.46	15.48
		Transfer change (baseline) (%)	
	−12.03	−14.55	−16.62
LS (EA&HI)			
ρ=0.014	−81,642	−79,655	−76,990
ρ=0.028	−80,080	−79,236	−77,247
ρ=0.0653	−74,400	−77,210	−77,400
MS (EA&HI)			
ρ=0.014	2,657	−22,494	−37,608
ρ=0.028	9,293	−18,616	−35,426
ρ=0.0653	29,508	−6,695	−28,610
HS (EA&HI)			
ρ=0.014	109,291	44,598	5,326
ρ=0.028	120,461	51,326	9,361
ρ=0.0653	153,394	71,220	21,346
Tax change (EA&HI) (%)			
ρ=0.014	0.08	3.42	6.21
ρ=0.028	−1.05	2.34	5.19
ρ=0.0653	−3.87	−0.40	2.59
Transfer change (EA&HI) (%)			
ρ=0.014	−0.10	−4.03	−7.22
ρ=0.028	1.28	−2.79	−6.09
ρ=0.0653	4.87	0.49	−3.11

Source: Authors' calculations.
Note: Present value in 2010 euros.

Table 10 allows us to verify the extent to which our results are sensitive to the choice of discount rate. Thus, different discount rates significantly change the generational accounts of newborns, which is not surprising. By contrast, the differences between the baseline scenario and the EA&HI scenario, resulting from the inclusion of the increase in average human capital, are extremely stable The same conclusion can be drawn concerning the necessary economic policy adjustments: the inclusion of human capital substantially improves the assessment of the sustainability of fiscal policy.

Concerning the impact of heath on productivity, we retain in our benchmark simulation the intermediate value from the study of Bloom and Canning (2005) (ρ=2.8 percent). We now test the sensitivity of our results to alternative values of ρ by using the estimations of Weil (2007) (ρ=6.53 percent) and Barro (2013) (ρ=1.4 percent). As we have demonstrated that improving the health of workers has a significant impact on their productivity, here we naturally observe substantial variation in our results in response to variations in ρ (Table 10). For a given interest rate, the required increase in taxes changes by approximately 4 percentage points across the different values of ρ. However, such changes do not affect the significance of the positive effect arising from improvements in individual health status in the assessment of the sustainability of fiscal policy. This leads to the question of which type of health expenditure to implement to increase workforce productivity.

6. Conclusion

The usual argument is that expected demographic changes threaten the sustainability of fiscal policies. However, the assessment of the economic costs of population aging is difficult for two main reasons. First, an important share of the economic effects of aging remain in the future and have to be evaluated under conditions of considerable uncertainty. Second, many of the mechanisms that transmit demographic changes in the economic sphere are complex and do not allow us to conclude with certainty in favor of a positive or negative effect. Generational accounting is generally considered as a meaningful approach to evaluating fiscal policy. All studies using this tool reveal a large generational imbalance that demands profound reform of budgetary or fiscal policy.

However, these studies do not account for the positive effects of aging in terms of human capital accumulation. This change is important from the budgetary perspective because it substantially modifies the fiscal means and needs of successive cohorts. Thus, a rise in the educational attainment of successive generations affects the growth rate of labor productivity and thus influences the average age profile of taxpayers and recipients of transfers over time. In parallel, while improving the health status of each age class of the population contributes to the aging of the population, this improvement can also be an asset to the economy. Indeed, longer life can be likened to a rejuvenation of the labor force, that can then improve the productivity of individual workers.

In this paper, we have shown that including future changes in the skill structure of the population and the future improvements in the health of the population substantially affects the results of GA. Therefore, we estimate that the future change in the skill structure of the French population and the improvement in its health in the long term could reduce the tax burden bequeathed to future generations by 79 percent. These results are quite robust to our assumptions regarding future returns to skill, interest rates, and the impact of improving the health of the workforce on productivity. However, our results are more sensitive to assumptions concerning the educational structure of future cohorts.

Is this a sufficient reason to abandon the very negative view of the impact of aging on public finances? We should remain cautious regarding the generalizability of our results. We should bear in mind that GA is a purely mechanical tool. It does not account for all of the interdependencies between demography and the economy. In reality, there are multiple economic impacts of aging, which operate through many different mechanisms that are not accounted for by our model of partial equilibrium. Thus, the main contribution of this study is to show the extent to which the long-term effects of aging on fiscal policy are sensitive to the assumptions made regarding the accumulation of human capital. Therefore, the integration of generational accounts, human capital, and fiscal policy within the framework of a general equilibrium model is obviously a promising subject, but one that we must leave for future research.

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