Aging, Health Status, and Productivity in France: A Generational Accounting Perspective

(Preliminary version)

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Abstract:

The increase in life expectancy is the main source of aging in OECD countries. The aim of this paper is to highlight the productivity gains resulting from the increase in life expectancy. To do this, we build a Generational Accounting Model applied to French economy. With the conventional methodology of Generational Accounting, we first estimate necessary adjustments to ensure the sustainability of French fiscal policy in the long term assuming that individual taxes and transfers grow at the same pace as labor productivity. However, this assumption doesn't take account the explicit determinants of individual productivity. For that reason, we then partially explain the productivity growth by the skills level of French population as well as its health, which is approximated by the survival rate of adults. With this new methodology, we show that the increase in life expectancy in France will generate potential important productivity gains that could significantly challenge the weight of the burden induced by aging. Therefore, we estimate that the future deformation of the skill structure of French population and the improvement of its health in the long term reduce by 90% the tax burden bequeathed to future generations.

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Keywords: Generational Accounting, Health Status, Education, Productivity, Aging, Fiscal Policy.

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1 Introduction

According to INSEE official forecasts, French population should increase by 19,3% between 2007 and 2060, from 61 795 238 to 73 557 857 persons. However, French working population, population aged between 15 and 64 years, should grow by only 3.89 % over the same period, while the share of population aged 65 and over should increase by 92.42 %, from 10 208 292 to 19 642 618 people. These demographic evolutions could induce a significant increase of old age dependency ratio, the ratio between population aged 65 and over to population aged 15 to 64 years, in the coming decades. The old age dependency ratio was equal to 25,35% in 2007 and could equal to 46,96% in 2060. These demographic trends confirm the fact that French population aging at the top of the age pyramid.

The significant increase in French life expectancy in recent decades has contributed largely to this aging at the top of the age pyramid. The life expectancy at birth in France increased from 76.86 years in 1975 to 83.78 years in 2005 for women and from 68,99 years in 1975 to 76,76 years in 2005 for men. According to INSEE baseline forecast, this trend should not be reversed in the long term. The life expectancy at birth could be equal to 88.99 years for women and 83.82 years for men in 2050. This continuous increase in French life expectancy is the result of many technological progress in medical field and the success of health policy conducted in France after the Second World War.

Nonetheless, this continuous increase in French life expectancy could become a threat to French social model. The fast growth of elderly's share in French population could lead to a significant growth of health and retirement expenditures. In 2010, retirement expenditures represented 13,8% of GDP but they could reach 14,2% of GDP in 2020 and could range between 12.8% and 15.8% of GDP in 2060 (Conseil d'Orientation des Retraites 2012). In addition, there is a consensus today to admit that agents aged 65 and over spend more in health than agents aged under 65. That's why French population aging has become a key determinant of health expenditures growth in France. In 2010, health expenditures represented 11.2% of French GDP but they could represent 13.6% of GDP in 2060 (Chojnicki, Defoort, Drapier & Ragot 2010).

Unfortunately, the slow growth of French working population could not able to absorb this increase of social expenditure. That's why the budget of French Social Security could accumulate deficits in long term. The deficit of French Social Security represented 0.8% of GDP in 2010 but would reach 3% of GDP in 2060 (Chojnicki et al. 2010). And if French government won't make fiscal adjustments, French fiscal policy would not be sustainable in the long term (Chojnicki 2011). These few studies highlight negative effects of aging on government budget. At the opposite, we think that the continuous increase in French life expectancy could have too some positive effects on economy. Health improvement which allowed the aging at the top of the age pyramid could improve labor productivity.

Thus, in this paper we highlight the productivity gains induced by the continuous increase in French life expectancy. To do this, we develop a Generational Accounting Model (GAM) applied to French case in which we explain the productivity growth by the evolution of skills level and health status of population. First, we use the conventional methodology of Generational Accounting (Auerbach, Gokhale & Kotlikoff 1991). This conventional methodology gives our baseline scenario in which we update the assess of fiscal burden induced by French population aging. The baseline results show that aging could generate an Intertemporal Public Liability (IPL) evaluated to 1 736 billions €. French government should increase all taxes by 7,68% or decrease all benefits by 8,66% in order to ensure the sustainability of French fiscal policy in the long term. Second, we build scenario 2 in which we insert Chojnicki & Docquier (2006) methodology in our GAM. This methodology allows us to take account the effect of the future deformation of the skills structure of French population on government budget. The scenario 2 results indicate that the productivity gains obtained from the future deformation of the skills structure of French population could reduce by 67% tax burden due to aging. Third, we construct scenario 3 in which we improve the future skills structure of French population. Productivity gains obtained from this improving could generate fiscal surplus in the long term. And even if, we obtain these results assuming that labor productivity grows at a constant rate each year, Chojnicki & Docquier (2006) methodology allows us to capture implicitly the productivity gains from education.

Fourth we build scenario 4 in which we keep the same future deformation of the skills structure of French population as in scenario 2, but we consider now the effect of health status on labor productivity. This is the aim contribution of this paper. To do this, we rely on work of Bloom & Canning (2005) and Weil (2007) among other. These authors estimate the magnitude of the effect of health status on labor productivity. We include their estimates in our GAM assuming that the Average Survival Rate (ASR) is a good proxy of health status. In this scenario, labor productivity depends on skills level and health state that we disaggregate too by skills level. Scenario 4 results show that French population aging could induced productivity gains. These productivity gains generate fiscal gains which allow to reduce by 90,21% IPL. Tax adjustments necessary to ensure budget balance become then minimal. Government should increase all taxes by only 0.61% or decrease all benefits by only 0.52%. Fifth, we construct scenario 5 in which we keep the future deformation of the skills structure of French population used in scenario 3 and apply our new simulation method on this scenario. The simultaneous improvement of the skills structure and the health status of French population should generate productivity gains able to reduce IPL by 153,75%.

In brief, we show in this paper that French population aging is not the main threat to fiscal sustainability. The health status improvement causing French population aging generates productivity gains which appear like fiscal gains in our GAM.

The rest of this paper is organized as follow. Section 2 describes briefly the Generational Accounting Model (GAM). Section 3 discusses data and hypothesis used in our GAM. Section 4 compares baseline results to scenario 2 results. Section 5 summarizes scenario 3 results. Section 6 explains how we take account health status in our GAM. Sections 7 and 8 give scenarios 4 and 5 results. And we conclude with section 9.

2 The Generational Accounting Model

Generational Accounting Model (GAM), initiated by Auerbach et al. (1991), allows to assess the intra and intergenerational distribution of public debt and the long term sustainability of fiscal policy. Auerbach et al. (1991) create GAM to analyze the effects of the deformation of the age structure of American population on US fiscal policy. Thereafter, Chojnicki & Docquier (2006) used GAM method to study the consequences of the future deformation of the skills structure of American population on US fiscal policy. In this paper, we resort to GAM to evaluate the sustainability of French fiscal policy in the long run.

GAM is derived from the Overlapping Generations, General-Equilibrium Model (OLG-GEM) which has reached its steady state. From this steady state, the OLG-GEM evolves along a balance growth path (BGP). Thus, GAM analyzes the evolution of Intertemporal Budget Constraint of government along this BGP. Here, we suppose that French economy will reach his steady state in 2018. And from 2018 to 2215, individual taxes and transfers grow at the same pace as labor productivity. So, we define the Intertemporal Budget Constraint of French Government as in equation (1)

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

According to equation (1), French Government Budget is balanced when the present value of government purchases, PVG_t, less the public net wealth, W_t, equalize 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.

We obtain the present value of government purchases with equation (2)

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

in which i is the interest rate.

Assuming that each agent lives during D years and distinguishing three skills level (L: low skills, M: medium skills and H: high skills), equation (3) gives the present value of net tax payments by living generations over the rest of their lives,

$$PVL_t = \sum_{j=0}^{D} \left(n_{j,t}^L p_{j,t}^L + n_{j,t}^M p_{j,t}^M + n_{j,t}^H p_{j,t}^H \right) \tag{3}$$

in which $p_{j,t}^X$ describes the relative share of cohort j with X skill at t in population. $n_{j,t}^X$ represents the generational account of cohort j with X skill at t such as

$$n_{j,t}^X = \frac{1}{p_{j,t}^X} \sum_{k=j}^{D} \frac{\theta_{k,t+k-j}^X p_{k,t+k-j}^X}{(1+i)^{k-j}} \qquad j = 0, ..., D \qquad X = L, M, H \tag{4}$$

$\theta_{k,t+k-j}^X$ gives the net tax payment by a representative agent of type X at time $t+k-j$.

To evaluate the sustainability of fiscal policy, we compute too PVF_t^* which is the hypothetical generational accounts of future cohorts under assumption that current fiscal policy will be maintained in the future. We obtain PVF_t^* with

$$PVF_t^* = \sum_{s=t+1}^{\infty} \sum_{j=0}^{Min[s-t-1;D]} \frac{\theta_{j,s}^L p_{j,s}^L + \theta_{j,s+j}^M p_{j,s}^M + \theta_{j,s+j}^H p_{j,s}^H}{(1+i)^{s-t}} \tag{5}$$

So, the difference between PVF_t and PVF_t^* gives the Intertemporal Public Liabilities (IPL). The sustainability of current fiscal policy depends on the sign of IPL. If $IPL > 0$, current fiscal policy is unsustainable in the long term. If $IPL = 0$, fiscal policy is sustainable. And if $IPL < 0$, current fiscal policy could generate fiscal surplus in the long run. Furthermore, IPL assess gives too the magnitude of necessary fiscal adjustments to ensure fiscal sustainability if $IPL > 0$. Thus, a very high IPL implies a very strong fiscal adjustments and conversely[1].

3 Data and Hypothesis

3.1 Population forecasts

First, we calibrate the demographic part of our GAM with INSEE population forecasts. INSEE population forecasts give the evolution of French population between 2007 and 2060 (see Table 1). But, we need to extend these official forecasts until 2215 to increase the simulations' accuracy. So, we use the component method to extend French population forecasts until 2215. The component method allows us to estimate population structure by sex and by age for each year between 2061 and 2215, according to births, deaths and net migration from the previous year. And we assume that fertility, net immigration and mortality rates for each age and for each sex remain at their 2060 level.

Second, we disaggregate our population forecasts according to 3 skills level (LS, MS and HS) to take account the skill structure of French population. LS is composed by population who has

[1]See Chojnicki & Docquier (2006).

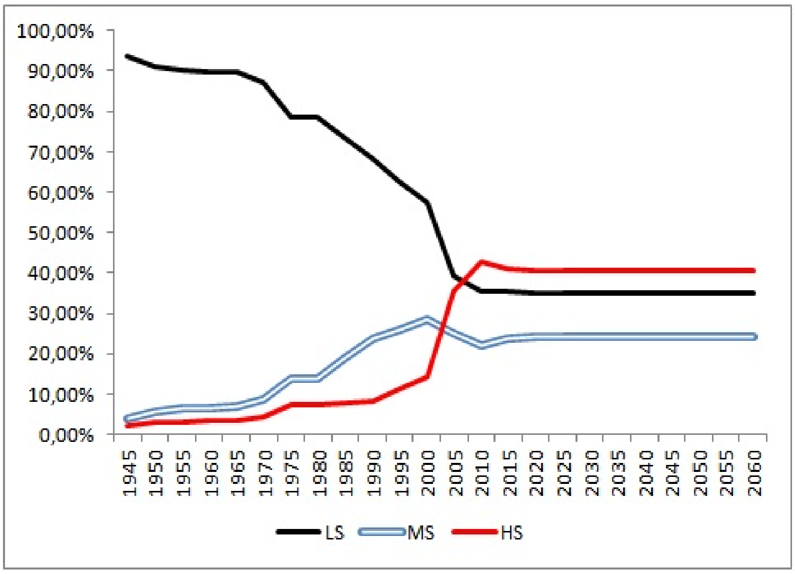
Table 1: The evolution of French population from 2007 to 2060

	2007	2020	2060
Total population	61 795 238	65 961 631	73 557 857
Population aged 15 to 64 years	40 266 158	40 704 410	41 831 202
Population aged 65 years and over	10 208 292	13 453 391	19 642 618
Old age dependency ratio (+65/15-64)	25,35%	33,05%	46,96%

Source:INSEE

education level lower than baccalaureat (BAC). MS is formed by population who has made 2 years of university study after BAC. And HS is composed by population who has made more than 2 years of university study after BAC. The size of each skill level is given by French population census of 2005-2006. However, skills level of agent aged under 25 are not informed in French population census. That's why, we assume that agent aged under 25 in 2010 will inherit of skills level of their parents. We assess then the relative share of each skill level in each cohort in 2010. And we suppose that these relative shares remain constant after 2010. Thus, we obtain the trend of the future deformation of the skills structure of French population until 2060 drawn in Figure 1.

Figure 1: The deformation of the skills structure of French population aged 30 to 34 years between 1945 and 2060



3.2 French government budget

The receipts of French government are: Labor Income Tax (IRPP), Capital Income Tax (Patrimoine), Excise taxes (TVA), Council Tax (Impôts locaux), CSG & CRDS[2], National Insurance Contributions (Cotisations Sociales) and the other taxes. Table 2 gives the share of each tax in GDP and in government receipts.

These receipts of government finance French government expenditures which are: Social Security Benefits, Housing, RMI, Unemployement Benefits, Child & Youth benefits, Health Expenditures

[2]CSG is the "Contribution Sociale Généralisée" & CRDS is the "Contribution pour le Remboursement de la Dette Sociale"

Table 2: The receipts of French government in 2010

	Labor Income Tax	Capital Income Tax	Excise taxes	Council Tax	CSG-CRDS	National Insurance Contributions	Other taxes
share in GDP (%)	2,40	2,70	10,90	2,10	4,60	18,60	8,00
share in government receipts (%)	4,90	5,60	22,00	4,30	9,30	37,70	16,20

and Education Expenditures. Table 3 gives the share of each expenditure in GDP and in total government expenditures.

Table 3: The expenditures of French government in 2010

	Social Security benefits	Housing	RMI	Unemployement benefits	Child & Youth benefits	Health expenditures	Education expenditures	Other expendiures
share in GDP (%)	14,40%	0,80%	0,80%	2,20%	2,90%	11,00%	7,00%	15,30%
share in government expenditures	25,40%	1,50%	1,40%	3,90%	5,10%	19,40%	12,30%	27,00%

We estimate the evolution of French government receipts and expenditures between 2010 and 2012 with data from National Account and Social Security Account. For the period 2013-2017, we make the same estimates with "*Projet de Loi de Finance 2013*" data and with "*Conseil d'Orientation des Retraites*" (COR) official forecasts (Conseil d'Orientation des Retraites 2012). After 2017, we assume that all taxes and transfers grow at the same pace as labor productivity. Labor productivity is supposed to grow by 1,3% each year from 2018[3].

Moreover, we construct a profil per age and per skill level for each tax and for each transfer. We compute these profils with data from "Enquête Budget des Familles" (INSEE, 2006) and from "Enquête Santé et Protection Sociale" (IRDES ,2006). We assess too Education expenditure profil per age and per skills level exploiting data from Ministry of National Education [4]. We obtain then the profil per age and per skill level for payment of all taxes (figure 2), for receiving of all transfers (figure 3), and for payment of net taxes (figure 4) in 2010.

Figure 4 shows for example that the net tax payment of HS during working life is three to four times greater than that of the LS. The net tax payment of MS is twice as large as that of the LS during working life. However, figure 3 shows that HS people receive on average twice more benefits from French government than LS when they are retired.

4 Baseline and scenario 2 results

Our baseline results are obtained by using the conventional methodology of Generational Accounting (Auerbach et al. 1991). The generational accounts of living generations in 2010 estimated with this method are summarized in the first part of Table 4. We see that, in average, the taxes paid by working cohorts exceed benefits received by them over the rest of their life. But this is not the case for newborns generation and all retired generations in 2010.

[3]This is the growth rate of labor productivity used by Conseil d'Orientation des Retraites (2012) in the scenario C of their forecasts

[4]In France, Ministry of National Education evaluates each year the theoretical cost of education for an age reaches a given skill level

Figure 2: Tax profile per age and education (Present Value in 2010 €)

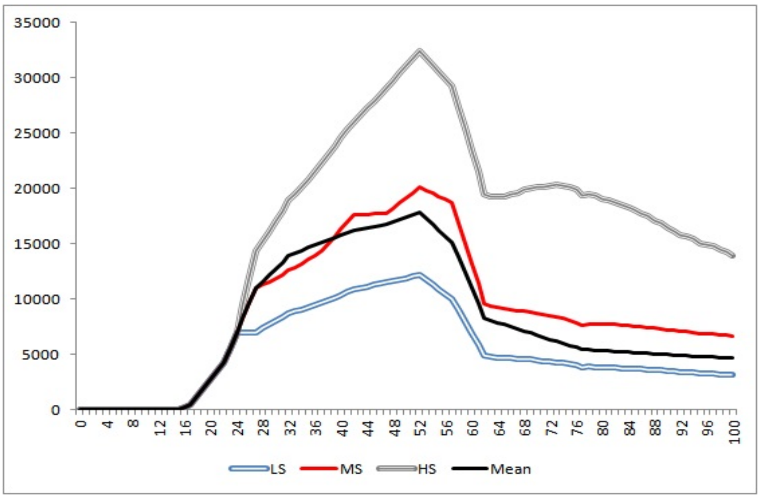


Figure 3: Transfer profile per age and education (Present Value in 2010 €)

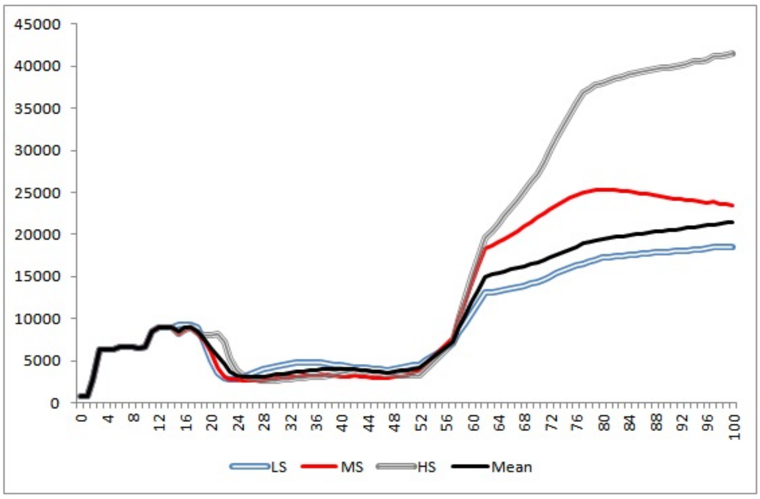
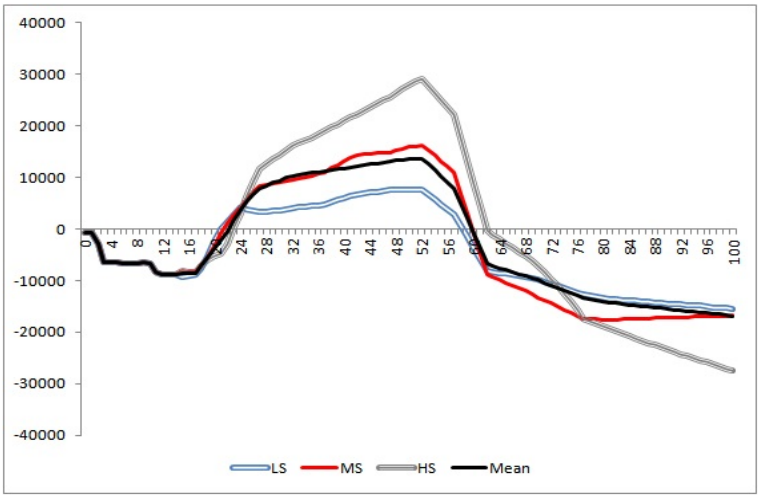


Figure 4: Net taxe profil per age and per education (Present Value in 2010 €)



We evaluate too French fiscal sustainability with this conventional methodology. Originally, French public debt is evaluated to 1 109 billions € in 2010. But we find that the future deformation of the age structure of French population should induce an increase of public debt in the long term. Indeed, IPL is 52% more important than French public debt in 2010. According to this result, French fiscal policy could not be sustainable in the long run. The net tax payments over the rest of life of the living generations in 2010 would not be enough to reimburse public debt evaltuated in 2010. To ensure fiscal sustainability, French government should then increase by 7,76% all taxes or decrease by 8,76% all transfers.

However, the conventional methodology of Generational Accounting overstates tax burden generated by aging because it doesn't take account the productivity gains from the future deformation of the skills structure of French population (Chojnicki & Docquier 2006). That's why it is important to include skills heterogeneity in GAM[5]. In scenario 2, we apply then Chojnicki & Docquier (2006) method to our GAM assuming that there are three skills level (LS, MS and HS) in French population. The future deformation of the skills structure of French population that we use here is drawn in Figure 1. The generational accounts of living generations in 2010 estimated with Chojnicki & Docquier (2006) method are summarized in the second part of Table 4.

The comparison of baseline results and scenario 2 results shows that all newborns generation in 2010 have not a negative generational account. HS newborns generation in 2010 have a positive generational account. Otherwise, baseline results show that all generations above 60 years in 2010 receive more transfers than pay taxes. Scenario 2 results indicate that LS generations have negative generational account at age 50 while HS generations have negative generational account only at 70 years. Moreover, in baseline scenario, the net tax payment of generation aged 30 is equal to 233 156€. But when we consider skills heterogeneity, we see that, for the same age, LS generation have 23% lower net tax payment than 233 156€ and HS generation have twice more. Thus, skills heterogeneity induces an heterogeneity of net tax payment (Figure 5).

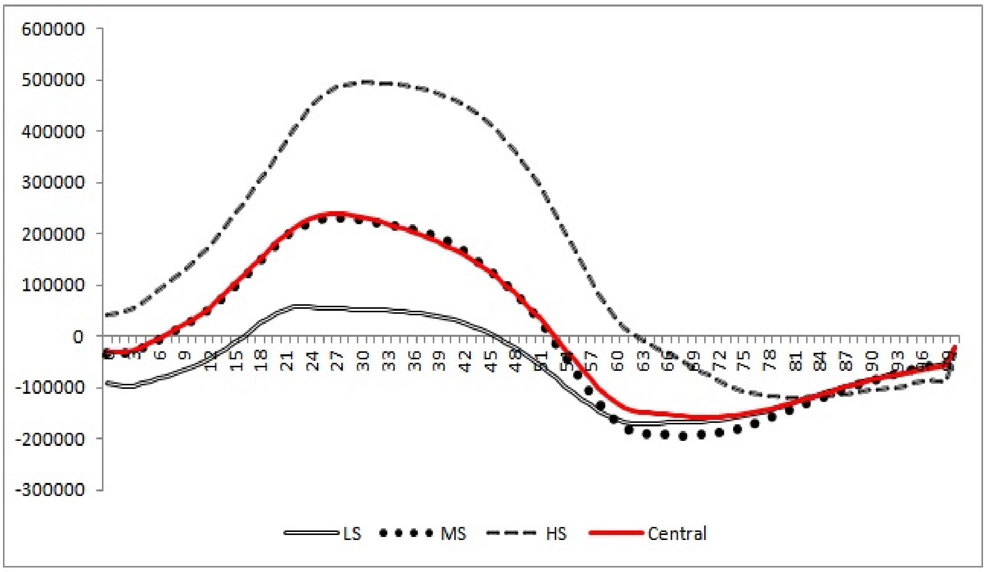
Furthermore, when we take account skills heterogeneity, tax burden bequeathed to future generations decreased by 67% compared to baseline scenario. In scenario 2, IPL is estimated to 561 billions €. This result highlights the productivity gains from the future deformation of the skills structure of French population. Indeed, these productivity gains generate fiscal gains which allow to reduce tax burden induced by aging in the long run. Nevertheless, these fiscal gains are not enough to vanish fiscal burden. That's why French government should increase all taxes by 2,35%

[5]In GAM with skills heterogeneity, Chojnicki & Docquier (2006) show that productivity gains appear like fiscal gains.

Table 4: Generational accounts of living generations (a)

	Present value of taxes	Present value of benefits	Generational accounts
		Baseline scenario	
0	168086	-198078	-29992
20	389693	-205758	183935
30	461663	-228507	233156
50	347073	-294606	52467
60	219311	-348404	-129093
70	147770	-305054	-157284
100	7657	-30903	-23246
		Scenario 2	
		Low Skill	
0	109597	-199701	-90104
20	253191	-206736	46455
30	287890	-235404	52485
50	220309	-264329	-44020
60	137504	-300188	-162684
70	98623	-265104	-166481
100	5282	-26951	-21669
		Medium Skill	
0	163747	-195574	-31827
20	380850	-200588	180262
30	459528	-233251	226277
50	392057	-342511	49546
60	261820	-428836	-167016
70	189881	-382393	-192511
100	10631	-32515	-21884
		High Skill	
0	253592	-211833	41759
20	592359	-239035	353324
30	760394	-265812	494582
50	727200	-408674	318526
60	569833	-536091	33743
70	462343	-530421	-68079
100	21550	-57576	-36026
Note:	Present value in 2010 euros		
Source:	Authors' calculations		

Figure 5: Generational account per living cohort (baseline scenario and scenario 2 - Present Value in 2010 €)



or decrease all transfers by 2,77%. The effects of restoring the budget balance through tax or transfer adjustments on newborns generational accounts are summarised in Table 5.

In brief, in this section, first, we show that the conventional methodology of Generational Accounting overstates fiscal burden induced by French population aging. Second, we find that the future deformation of the skills structure of French population should generate productivity gains which could reduce fiscal adjustment to ensure balanced budget. Third, unfortunately, these productivity gains are not enough to warrant a sustainability of French fiscal policy.

5 Scenario 3 results

According to Figure 4, HS pay more net tax than LS and MS during their working life. Furthermore, we see through scenario 2 results that LS has the lowest productivity. So, we use these facts to construct scenario 3. In this scenario, we improve the skills structure of French population in the long term. In scenario 2, the relative share of LS in each cohort is equal to 35,21% in 2060 but we halve this relative share to reach 17,61% in 2060. And we put to 50% the relative share of HS in each cohort in 2060 (40,44% in scenario 2). We draw in Figure 6 this new future deformation of the skills structure of French population.

With this new future deformation of the skills structure of French population, we note a degradation of generational accounts of MS and HS (see Table 6). This result is due to high transfer received by MS and HS when they leave labor market (see Figure 3). Thus, an increase of the relative share of MS and HS in each generation induce a growth of benefits towards these peoples. Moreover, the halving of relative share of LS in each cohort doesn't provide a significant change in LS generational account. Nevertheless, the productivity gains from this new future deformation of the skills structure of French population are substantial. These productivity gains produce fiscal gains which generate a fiscal surplus in the long run. IPL is reduced by 108% compared to baseline scenario. This scenario shows that improving the skill structure of population is another way to ensure balanced budget in France.

However, we caution you that, first, this skill structure improvement is an arbitrary change because

Table 5: Generational imbalance (Scenario 2 (a))

	Present value of taxes	**Present value of benefits**	**Generational accounts**
		Newborns' generational account	
LS	109597	-199701	-90104
MS	163747	-195574	-31827
HS	253592	-211833	41759
		Restoring the balance through tax adjustment (+2.35%)	
LS	112174	-199701	-87527
MS	167598	-195574	-27975
HS	259557	-211833	47724
		Restoring the balance through transfer adjustment (-2.77%)	
LS	109597	-194164	-84568
MS	163747	-190151	-26404
HS	253592	-205959	47633

Note: (a) Present value in 2010 euros
Source: Authors' calculations

Figure 6: The new future deformation of the skills structure of French population aged 30 years between 2008 and 2060 (Scenario 3)

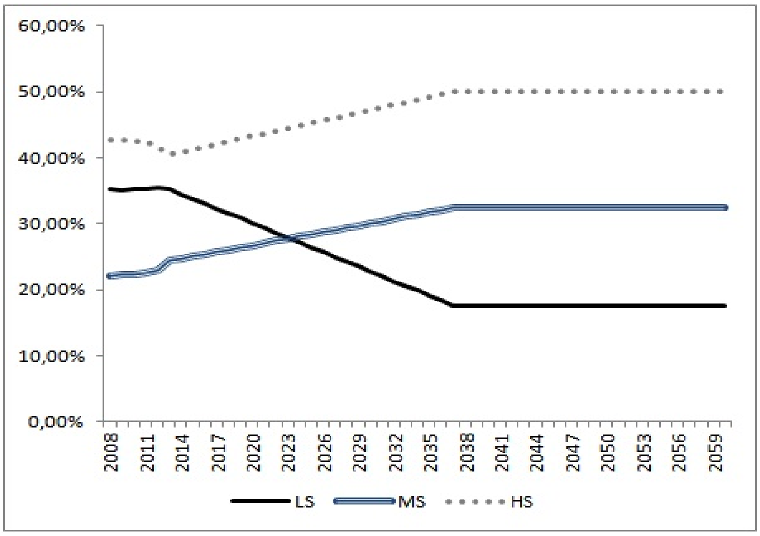


Table 6: Generational imbalance (Scenarios 2 & 3 (a))

	Newborns' generational account	
	Scenario 2	**Scenario 3**
LS	-90104	-90140
MS	-31827	-31913
HS	41759	41531
	Restoring the balance through tax adjustment (+2.35%)	**Restoring the balance through tax adjustment (-0.03%)**
LS	-87527	-90169
MS	-27975	-31957
HS	47724	41464
	Restoring the balance through transfer adjustment (-2.77%)	**Restoring the balance through transfer adjustment (+0.03%)**
LS	-84568	-90203
MS	-26404	-31976
HS	47633	41464

Note: **(a) Present value in 2010 euros**
Source: **Authors' calculations**

we don't have in France an official forecast of future skill structure in the long term[6]. Second, we assume in this scenario that education expenditures evolve at the same pace as productivity growth rate while improving skill structure should require more education expenditures than in scenario 3. Third, we suppose no variation of skill premiums while changing skill structure should induce necessarily a modification of skill premiums. We are aware of limits of these assumptions but the aim of this scenario is only to study the main effects of a shock of this kind on public finance.

6 Taking account the health variable in our GAM

In the baseline scenario (section 4), all taxes and transfers evolve at the same rate as productivity growth. We assumed that no significant change in the productivity growth could occur because the productivity increased at the same rate each year (+1,3% each year). We left partially this assumption in scenarios 2 and 3 because in these scenarios we have been able to capture the productivity gains induced by the future deformation of the skills structure of French population (section 5). But in scenarios 2 and 3, we always assumed that the growth rate of all taxes and all transfers was equal to $+1,3\%$ each year. So, in scenario 4, we will try to give up totally this assumption by explaining the variation of labor productivity in long term only by the variation of population health state. We propose here a new simulation method.

This new simulation method is based on Grossman (1972) and Nelson & Phelps (1966) theoretical works. Grossman (1972) and Nelson & Phelps (1966) show theoreticaly that people with better health could produce more. This theoretical insight was confirmed later by Bloom & Canning (2005), Weil (2007) or Barro (2013) (see Table 7). To obtain these empirical results, these authors used survival rate of adults (SRA) or life expectancy of population as a proxy of health status of working population. For example, Bloom & Canning (2005) find that an increase of SRA by 0.01 should grow the productivity by 2,8%.

Furthermore, according to Table 1, French life expectancy has improved significantly during last decades. This is the main source of French population aging. And this life expectancy improvement has been achieved through an overall health state improvement of French people. Thus, if life expectancy reflected objectively health status, the future life expectancy increase (see Table 1)

[6]To our knowledge, no official forecast describing the future skill structure of French population in mid and long term has available today.

Table 7: The assess of health's effect on labor productivity (ρ)

References	Health indicator	ρ
Bloom & Canning, (2005)	Average Survival Rate	0.028
Weil, (2007)	Average Survival Rate	0.0653
Barro, (2013)	Life expectancy at birth	0.018

should mean the pursuit of health state improvement of French, at least until 2060. Moreover, according to theoretical and empirical studies, better health generate greater productivity. That's why, we think that the future increase in life expectancy should induce a future improvement of labor productivity in France. To confirm this hypothesis, we construct scenario 4 in which we explain the variation labor productivity in long term only by the variation of population's health state.

We assume that productivity of population who has X skill level at t is g_t^X such as

$$g_t^X = \rho \times h_t^X \qquad X = L, M, H \tag{6}$$

h_t^X indicates the health status of population with X skill level at t and ρ assesses the influence of h_t^X on g_t^X. In spirit of Bloom & Canning (2005) and Weil (2007), we estimate French health status with SRA. First, we don't use life expectancy as a proxy of health status because this indicator underestimates the productive contribution of health (Aghion, Howitt & Murtin 2010). Second, we choose SRA because the data about the evolution of Survival Rate for each age, for each skill level and for each year between 2010 and 2060 are available in INSEE population forecasts.

Thus, we estimate the survival rate for each age, for each skill level and for each year with INSEE official life table. It is the same database that we used to expand our population forecasts. However, because of methodological issue, we can include only the average survival rate (ASR) of population aged 15 to 64 years into our GAM. We compute then the ASR for each skills level and for each year between 2010 and 2060. Thus, during this period, $g_t^L \neq g_t^M \neq g_t^H$. And from 2060, we assume that the ASR for each skill level remain constant until 2215. The growth of labor productivity for each skill level and for each year explained by the evolution of ASR is drawed in Figure 7.

7 Scenario 4 results

Assuming that $g_t^X = \rho \times h_t^X$ with ρ equal to 0.028 (Bloom & Canning 2005) and assuming that the future deformation of the skills structure of French population is the same as in scenario 2 (see Figure 1), we obtain the generational accounts summarized in Table 8.

According to Table 8, LS net tax payments in scenario 4 are lower than in scenario 2. The net tax payment of LS aged 40 is 67,25% lower than in scenario 2. On average, the net tax payments of all LS generations are reduced by 24.57% compared to the net tax payment of these generations in scenario 2. These results suggest that LS have much lower productivity when we explain the productivity growth by health status and by skill level. Second, Table 8 shows a little decrease in MS net tax payments. But this decrease is not significant like to LS. The net tax payment of MS aged 40 is reduced only by 11.29% compared to their net tax payment in scenario 2. Furthermore, MS net tax payments in scenario 4 increase by 11,05% and by 4,37% respectively for MS aged 60 and 70 years compared to scenario 2 results. Third, Table 8 shows that HS generations have much higher productivity than Chojnicki & Docquier (2006) simulation method suggest. HS net tax payments are three times greater in average than in scenario 2. However, the net tax payments of HS aged 50 and 60 decrease respectively by 1.65% and by 26.66% compared to net tax payments obtained in scenario 2.

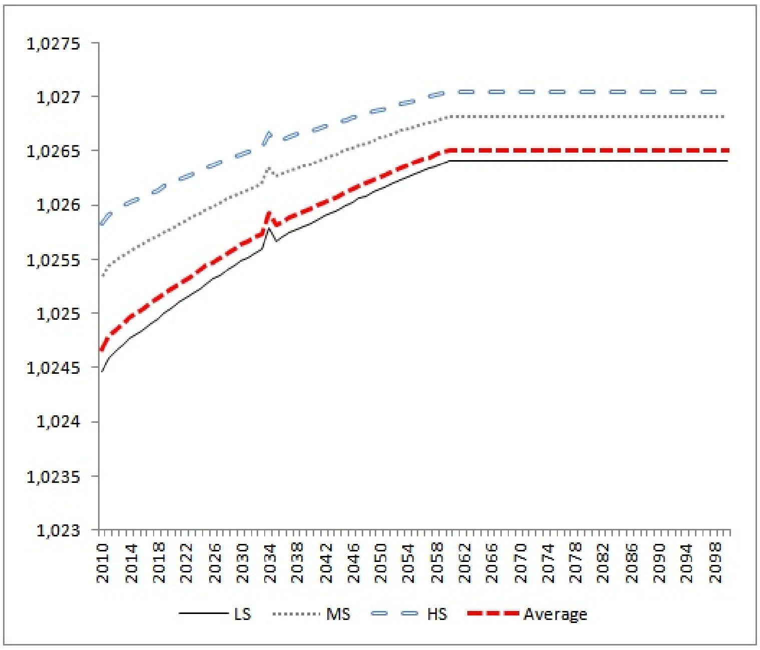
These results show that explaining the variation of productivity by health status and by skills

Table 8: Generational accounts of living generations (a)

	Scenario 2 (skills)	**Scenario 4 (skills & health)**
	Low Skill	
0	-90104	-95480
20	46455	36608
30	52485	34915
40	35465	11612
50	-44020	-67831
60	-162684	-178879
70	-166481	-174274
100	-21669	-21669
	Medium Skill	
0	-31827	-6974
20	180262	194032
30	226277	221897
40	184915	164033
50	49546	22891
60	-167016	-185488
70	-192511	-200924
100	-21884	-21884
	High Skill	
0	41759	125629
20	353324	429676
30	494582	542343
40	467589	482905
50	318526	313243
60	33743	24745
70	-68079	-74541
100	-36026	-36026

Note: **(a) Present value in 2010 euros**
Source: **Authors' calculations**

Figure 7: Growth of labor productivity explained by the evolution of survival rates between 2010 and 2100 with $\rho = 0,028$



structure increases the precision of the estimates provided by GAM. Our method improves the assessing of productivity of each class of population by weighting the productivity gains provided by better education for people's health. Thus, we highlight a differential productivity much more important between LS and HS than results obtained by Chojnicki & Docquier (2006) method suggest. The productivity gains from better education being more significant when we take account the health of working population. And these productivity gains always generate fiscal gains in our GAM.

Furthermore, we find that French population aging could also induce future productivity gains. Indeed, the health improvement of French population until 2060, that we can see through the increasing of the survival rates for each age group until 2060, could reduce by 90,21% IPL compared to baseline IPL. In the baseline scenario, IPL was equal to 1 695 billions € while it is equal to 166 billions € in scenario 4. When we introduce the future health improvement of French population in our simulation, we show that government could restore the budget balance by increasing all taxes by only 0,52% or by decreasing all benefits by only 0,62%. The consequences of these minimal fiscal adjustments on newborns generational account are shown in Table 9

In brief, explaining the variation of productivity only by the variation of the health state of working population permit us: (i) to take account the influence of health status on labor productivity, (ii) to have a non-constant growth rate of labor productivity over the time and non-homogeneous between 3 skills level, (iii) to highlight much more pronounced productivity differences between LS, MS and HS and (iv) to show that the future health improvement, which is the source of the future life expectancy increase, should improve labor productivity and could generate fiscal gains in the long term.

Table 9: Generational imbalance (Scenarios 2 et 4 (a))

	Newborns' generational account	
	Scenario 2	**Scenario 4**
LS	-90104	-95480
MS	-31827	-6974
HS	41759	125629
	Restoring the balance through tax adjustment (+2.35%)	**Restoring the balance through tax adjustment (+0.52%)**
LS	-87527	-94601
MS	-27975	-5593
HS	47724	127885
	Restoring the balance through transfer adjustment (-2.77%)	**Restoring the balance through transfer adjustment (-0.62%)**
LS	-84568	-93857
MS	-26404	-5304
HS	47633	127516
Note:	**(a) Present value in 2010 euros**	
Source:	**Authors' calculations**	

8 Scenario 5 results

In this section, we present our last scenario: scenario 5. We keep the same future deformation of the skills structure of French population as in scenario 3 on which we apply our new simulation method. Here, we want to assess the productivity gains from the simultaneous improvement of skills structure and health state of French population. Thus, we assume that the skill structure is like in Figure 6 and we explain the variation of productivity only by the variation of the health state of French working population.

We find that the simultaneous improvement of skill structure and health state of French population should generate productivity gains able to reduce IPL by 153,75% (see Table 10). The fiscal surplus induced by these productivity gains could be redistributed by increasing all benefits by 3,34% or by decreasing all taxes by 2,75%. The consequences of this fiscal redistribution on the newborns generational accounts are summarised in Table 11

Table 10: IPL and fiscal adjustments for different scenarios (a)

	IPL (billion € in 2010)	**Tax change**	**Transfer change**	**Tax & Transfer change**
Baseline scénario	1 695	7,76%	-8,76%	4,12%
Scenario 2	561	2,35%	-2,77%	1,27%
Scenario 3	-129	-0,03%	0,03%	-0,01%
Scenario 4	166	0,52%	-0,62%	0,28%
Scenario 5	-911	-2,75%	3,34%	-1,51%
Note:	**(a) Present value in 2010 euros**			
Source:	**Authors' calculations**			

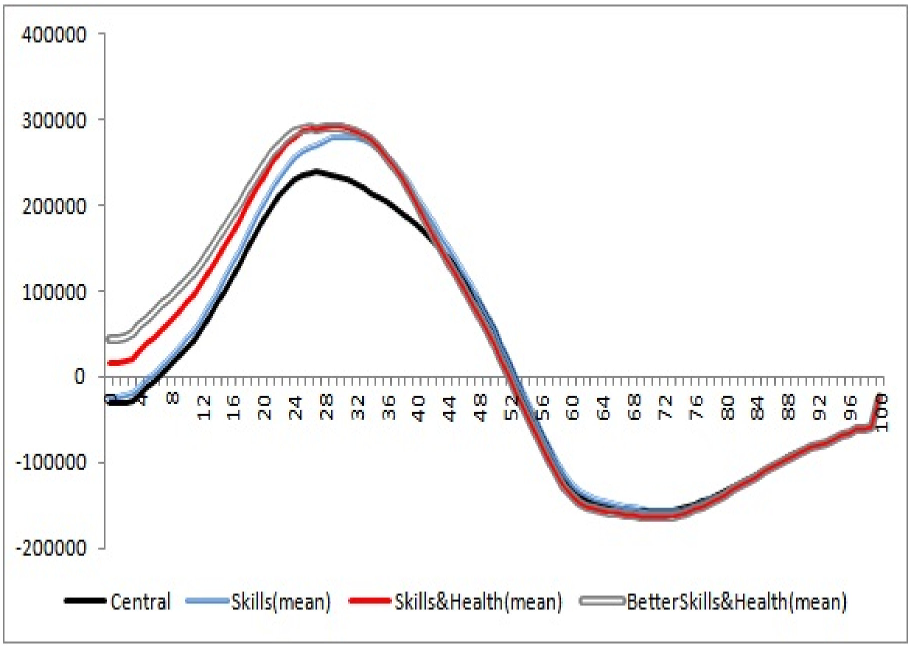
However, accordind to Figure 8, only generations aged under 20 in 2010 would enjoy to these productivity gains. We note too an average increase of the generational account of all cohorts aged under 20 in scenario 5 while the generational account of other cohorts don't vary significantly.

Table 11: Generational imbalance (Scenarios 4 & 5 (a))

	Newborns' generational account	
	Scenario 4	**Scenario 5**
LS	-95480	-95691
MS	-6974	-7292
HS	125629	125032
	Restoring the balance through tax adjustment (+0.52%)	**Restoring the balance through tax adjustment (-2.75%)**
LS	-94601	-100311
MS	-5593	-14549
HS	127885	113172
	Restoring the balance through transfer adjustment (-0.62%)	**Restoring the balance through transfer adjustment (3.34%)**
LS	-93857	-104511
MS	-5304	-16361
HS	127516	114791

Note: **(a) Present value in 2010 euros**
Source: **Authors' calculations**

Figure 8: Average generational account per living cohort for the different scenarios (Present Value in 2010 €)



9 Conclusion

In this paper, we show that including the future deformation of the skills structure of population and the future health state of population in a Generational Accounting Model are very important. Omitting these variables overestimates by 90% the fiscal burden induced by aging. Furthermore, explaining the productivity growth by these variables gives results much less pessimistic about the fiscal sustainability, despite the French demographic context.

We find that aging could have positive effects on public finance. When we include the future evolution of French health status in our simulation, we capture the productivity gains from better health which appear like fiscal gains in the long term. Our results are consistent with Bloom & Canning (2005), Weil (2007) and Barro (2013) results and confirm the Grossman (1972) and Nelson & Phelps (1966) theoretical insights.

Last, the main contribution of this paper is primarily methodological. To our knowledge, we are the first to introduce health variable in GAM. We managed to take account the effects of health status on labor productivity and we have a non-constant labor productivity over the simulation period and non-homogeneous between 3 skills level.

Nevertheless, GAM is a partial equilibrium model that's why we should over/underestimate the effects of health on labor productivity. Moreover, we estimate the health status of population with the Average Survival Rate. The question that arises is then to know if the survival rate is a good proxy of health or not?

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