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# Health Spending and Labor Productivity in an Aging Economy

Thèse présentée en vue de l'obtention du doctorat de Sciences Économiques par

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# Abstract

French population is aging and this demographic mutation should also occur in the coming decades. The negative economic effects of population aging are well-known but the magnitude of these effects depends partially on the evolution of labor productivity. To determine the evolution of labor productivity in France, this dissertation focuses on the economic effects of health spending. Indeed, on one side, health spending, by improving population's health status, affect positively labor productivity. On the other side, these health expenditures foster the aging process by extending population longevity. This dissertation aims then to check if productivity gains from health spending are enough to annihilate the negative economic effects of population aging. We demonstrate theoretically that private health spending generate a positive externality affecting positively labor productivity (Chapter I). However, our empirical results underline that this positive effect is limited when we consider the out-of-pocket expenditure on health (Chapter II). Thereafter, we assess the productivity gains resulting from the health status enhancement of French population by using a generational accounting model. It appears that the productivity gains should be significant but not enough to annihilate the negative economic effects of population aging (Chapter III). The simulation outcomes provided by our applied general equilibrium model confirm this result (Chapter IV).

**Keywords:** Economic effects of population aging, labor productivity, health status and health spending, general equilibrium model with overlapping generations.

# Résumé

Ma thèse part du constat que d'une part la population française vieillit et continuera de vieillir dans l'avenir. D'autres parts, la littérature économique met en garde sur les conséquences négatives de cette mutation démographique sur l'économie. Cependant, cette même littérature souligne que l'ampleur de ces conséquences dépendra entre autres de l'évolution de la productivité du travail. Partant de ce dernier constat, la thèse étudie donc l'évolution future de la productivité du travail en France en se focalisant sur le rôle des dépenses de santé. En effet, d'un côté, les dépenses de santé, en améliorant la santé, accroissent la productivité du travail. D'un autre côté, elles favorisent le vieillissement de la population en allongeant son espérance de vie. Sur quatres chapitres, la thèse tente ainsi de vérifier (i) s'il existe des leviers permettant aux dépenses de santé d'agir positivement sur la productivité du travail et (ii) si les gains de productivité générés par les dépenses de santé sont suffisamment importants pour annihiler les effets négatifs du vieillissement de la population.

Le premier chapitre de la thèse analyse les effets économiques des dépenses de santé destinées à améliorer la qualité de vie des individus. Un modèle à générations imbriquées est alors développé afin de montrer l'émergence d'une externalité intergénérationnelle induite par les dépenses de santé. En supposant que cette externalité agit positivement sur la productivité du travail des générations futures, je démontre que les dépenses de santé améliorant la qualité de vie peuvent aussi accroître la productivité du travail des générations futures. Il apparait alors qu'augmenter le poids des dépenses de santé améliorant l'utilité intertemporelle des agents permet aussi aux générations futures de bénéficier d'une productivité beaucoup plus élevée.

Le deuxième chapitre de la thèse étudie l'effet des dépenses de santé qui restent à la charge des individus[1] sur la productivité des salariés. Pour ce faire, un modèle théorique est développé afin d'établir les fondements microéconomiques du lien entre les dépenses de santé qui restent à la charge des individus et leur productivité. Une

[1]Les restes à charges sont la partie des dépenses de santé qui n'est ni remboursée par la Sécurité Sociale, ni remboursée par les mutuelles de santé

 

équation de salaire en est ainsi déduite et souligne un effet positif des dépenses de santé qui restent à la charge des individus sur la productivité. Ce résultat est testé empiriquement en exploitant la base de données SHARE. Cependant, les résultats empiriques suggèrent un effet limité des dépenses de santé qui restent à la charge des individus sur leur productivité.

Le troisième chapitre de la thèse quantifie les gains de productivité permis par la future hausse de l'espérance de vie des français. En effet, une hausse de la longévité traduit une amélioration générale de la santé. Or, la littérature économique suggère que cette amélioration peut générer des gains de productivité. Un modèle de comptabilité générationnelle est alors développé afin (i) de mettre à jour la mesure du fardeau fiscal dû au vieillissment démographique en France et (ii) de quantifier les gains de productivités issus de la future amélioration de la santé des français. L'originalité de l'approche réside dans l'explication de la future croissance de la productivité du travail par l'évolution de la santé des français, tout en tenant compte de la future amélioration de la qualification de la population. Il apparraît alors que les gains de productivité issus de la future hausse de l'espérance de vie ainsi que de la future amélioration de la qualification des français devraient réduire de 79% le fardeau fiscal induit par le vieillissment démographique.

Dans le même esprit, le chapitre quatre de la thèse mesure les gains de productivité issus de la future hausse des dépenses de santé en France. Un modèle d'équilibre général calculable à générations imbriquées est alors développé afin de tenir compte de l'effet simultané des dépenses de santé sur la productivité, le bien-être et l'espérance de vie tout en distinguant les dépenses de santé remboursées par la Sécurité Sociale et les mutuelles, et les restes à charge. Mes résultats suggèrent que la future hausse des dépenses de santé devraients fournir (i) des gains d'espérance de vie et de bien-être non-substantiels et (ii) des gains de productivité non-significatifs. Ce dernier résultat s'explique par le fait que la future hausse des dépenses de santé en France sera principalement permise par la hausse des dépenses de santé publiques. Or, ces dernières engendrent des effets d'éviction. Il apparait alors que les effets d'éviction générés par les dépenses de santé publiques devraient être beaucoup plus importants

 

que les gains de productivité permis par ces dernières.

**Mots clés:** Conséquences économiques du vieillissement de la population, productivité du travail, santé et dépenses de santé, modèle à générations imbriquées.

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# General introduction

French population experienced different changes over time. After the Second World War, the high fertility rate, 2.9 children per woman in 1950 (see Table 1), participated in French population growth. French population increased from more than 41 million in 1950 to over 53 million in 1980 (see Table 2). In other words, between 1950 and 1980, French population rose by more than 12 million (+29%). This significant expand in French population characterizes the *baby boom*. Due to *baby boom*, the age structure of French population had the following features: over 30% of French population was under 20 years-old in 1950 and over 50% were aged 20 to 59 years-old in 1990.

Table 1: Life expectancy and fertility rate in France (1950-2060)

| | | Life expectancy at | | |
|---|---|---|---|---|
| Year | Fertility rate | birth | 20 years-old | 60 years-old |
| 1950 | 2.9 | 66.1 | 51.4 | 17.0 |
| 1960 | 2.7 | 68.4 | 53.3 | 18.0 |
| 1970 | 2.5 | 69.5 | 54.3 | 18.9 |
| 1980 | 1.9 | 71.3 | 56.0 | 20.3 |
| 1990 | 1.8 | 73.7 | 58.2 | 22.1 |
| 2000 | 1.9 | 75.8 | 60.1 | 23.5 |
| 2010 | 2.0 | 77.7 | 62.0 | 24.8 |
| 2020 | 1.9 | 79.4 | 63.6 | 26.1 |
| 2030 | 1.9 | 80.9 | 65.0 | 27.2 |
| 2040 | 1.9 | 82.3 | 66.4 | 28.3 |
| 2050 | 1.9 | 83.6 | 67.7 | 29.4 |
| 2060 | 1.9 | 84.8 | 68.9 | 30.4 |

Sources: - INSEE
- Human Mortality Database (http://www.mortality.org/)
- Blanpain & Chardon (2010)
- Author's calculations

However, from 1980, fertility rate began to decrease slightly below 2 children per French woman. The decrease in share of population aged under 15 after 1980 illustrates this decline in fertility rate. The share of population under 15 years-old decreased from 22.5% in 1980 to 18.4% in 2010. Furthermore, from 1980 on, life expectancy increased significantly. Life expectancy at birth improved in average by 2 years per decade (see Table 1). The combination of decrease in fertility rate and rise in life expectancy then induced the expand in share of population aged 65 and over. Population aged 65 and over composed 14% of French population in 1980 against 16.8% in 2010. This increase in share of population aged 65 and over initiated the aging process of French population.

The common indicator to appreciate the aging process is the old-age dependency ratio (referred to below as OADR). OADR indicates the ratio between the size of population aged 65 and over, and the size of population aged 15 to 64 years-old. In France, OADR was equal to 17.2% in 1950 but reached 21.1% in 1990 (see Table 1). In 2010, OADR attained 25.9%. The evolution of OADR between 1950 and 2010 confirms the occurrence of aging process in French population.

Table 2: French population characteristics between 1950 and 2060

| | | | Share of population aged | | |
|---|---|---|---|---|---|
| Year | French population (in thousands) | OADR (a) | under 15 years-old | 15 to 64 years-old | 65 years-old and over |
| 1950 | 41 647 | 17.2% | 22.5% | 66.1% | 11.4% |
| 1960 | 45 465 | 18.7% | 26.2% | 62.1% | 11.6% |
| 1970 | 50 528 | 20.6% | 24.9% | 62.3% | 12.8% |
| 1980 | 53 731 | 22.1% | 22.5% | 63.5% | 14.0% |
| 1990 | 56 577 | 21.1% | 20.1% | 66.0% | 13.9% |
| 2000 | 58 858 | 24.6% | 18.9% | 65.1% | 16.0% |
| 2010 | 62 765 | 25.9% | 18.4% | 64.8% | 16.8% |
| 2020 | 65 962 | 33.1% | 17.9% | 61.7% | 20.4% |
| 2030 | 68 532 | 33.7% | 17.1% | 61.5% | 20.7% |
| 2040 | 70 734 | 34.3% | 16.7% | 61.2% | 21.0% |
| 2050 | 72 275 | 34.9% | 16.7% | 61.0% | 21.3% |
| 2060 | 73 558 | 35.5% | 16.4% | 60.8% | 21.6% |

Sources: - INSEE
- Blanpain & Chardon (2010)
(a) OADR: Old age dependency ratio

French official population forecasts (Blanpain and Chardon (2010)) indicate that aging process of French population should continue in the coming decades. OADR should reach 33.1% in 2020 and 35.5% in 2060 according to these population projections. Note that aging process in France should be driven by the increase in life expectancy and in no event by the drop in fertility rate in the coming decades. Indeed, to obtain their population forecasts, Blanpain and Chardon (2010) assume that fertility rate should stabilize at 1.95 children per woman. Even if this rate is below the one required to replenish French population, French fertility rate is high compared to fertility rate in Germany for example[2]. At the opposite, life expectancy at birth should increase by nearly 4 years between 2020 and 2060 in France. Life expectancy at birth should reach 84.8 years in 2060 against 79.4 years in 2020.

## The economic effects of population aging

These demographic changes should affect French economy. To illustrate the economic effects of population aging, let's consider a representative firm producing $Y_t$ at period $t$. For that purpose, the firm uses a physical capital and manpower indicated respectively by $K_t$ and $L_t$. For analytical convenience and following the usual assumptions on neoclassical production function, assume that the relationship between the output $Y_t$ and the inputs is described by a Cobb-Douglas function such that:

$$Y_t = A_t(K_t)^{\alpha}(L_t)^{1-\alpha} \tag{1}$$

with $A_t$ a scale variable and $\alpha > 0$ a parameter indicating the elasticity of substitution between $K_t$ and $L_t$.

On one side, population aging is first characterized by a decrease in size of active population, namely population aged 15 to 64 years-old indicated by $L_t$ in equation 1. As,

$$\frac{\partial Y_t}{\partial L_t} = (1-\alpha)A_t(K_t)^{\alpha}(L_t)^{-\alpha} > 0 \tag{2}$$

theoretically, population aging should reduce the output produced in economy. On the other side, population aging should increase the physical capital stock per worker.

[2]According to Federal Statistical Office (2009), the fertility rate should remain at 1.4 children per woman until 2060 in German.

Indeed, the physical capital stock per worker is given by $k_t$ such that:

$$k_t = \frac{K_t}{L_t} \quad \text{with} \quad \frac{\partial k_t}{\partial L_t} = -\frac{K_t}{(L_t)^2} < 0 \tag{3}$$

The first derivative of $k_t$ with respect to $L_t$ indicates that any decrease in size of workforce induces an increase in physical capital stock per worker. The workforce has then more available physical capital to produce output. The relationship between the capital per worker and output can be established by rewriting equation 1 such that:

$$y_t = A_t \left(k_t\right)^{\alpha} \quad \text{with} \quad y_t = \frac{Y_t}{L_t}$$

$y_t$ indicates then the output per worker. It follows that:

$$\frac{\partial y_t}{\partial k_t} = \alpha A_t \left(k_t\right)^{\alpha - 1} > 0 \tag{4}$$

Thus, any decrease in $L_t$ rises $k_t$ (see equation 3) and upgrades the level of $y_t$ (see equation 4). It seems that population aging should also increase the output per worker by rising the physical capital stock per worker. In sum, theoretically, population aging could reduce the aggregate output (see equation 2) and increase the output per worker (see equation 4).

To quantify the real effects of population aging on output, Krueger and Ludwig (2007) develop an applied general equilibrium model with overlapping generations calibrated on countries composing the Organisation for Economic Co-operation and Development (referred to below as OECD). Results obtained by these authors indicate that increase in output per worker resulting from the rise in $k_t$ should not compensate the decrease in output induced by the decline in size of workforce in OECD countries. Their benchmark results forecast a decrease in output per worker mainly in European countries until 2030.

Theoretically, the remuneration of manpower and physical capital stock should also vary with population aging. Denote by $w_t$ and $u_t$ the remuneration of respectively $L_t$ and $K_t$. To determine the optimal remuneration of $L_t$ and $K_t$, the representative firm maximizes its profit $\Pi_t$ such that:

$$\Pi_t = p_t \times A_t(K_t)^{\alpha}(L_t)^{1-\alpha} - w_t \times L_t - u_t \times K_t \tag{5}$$

with $p_t$ the price of $Y_t$. The first order conditions of the firm's problem involve that:

$$w_t = A_t(K_t)^{\alpha}(L_t)^{-\alpha} \times (1-\alpha) \tag{6}$$

$$u_t = A_t(K_t)^{\alpha-1}(L_t)^{1-\alpha} \times (\alpha) \tag{7}$$

by assuming as usual that $Y_t$ is the numeraire in economy and then $p_t = 1$. It follows that:

$$\frac{\partial w_t}{\partial L_t} = -\alpha \times (1-\alpha) \times A_t(K_t)^{\alpha}(L_t)^{-\alpha-1} < 0 \tag{8}$$

Thus, theoretically, according to equation 8, population aging characterized by a decrease in $L_t$ should improve the remuneration of labor. Moreover, equation 7 is equivalent to:

$$u_t = (\alpha) \times A_t(k_t)^{\alpha-1} \tag{9}$$

It follows that:

$$\frac{\partial u_t}{\partial k_t} = (\alpha-1)(\alpha) \times A_t(k_t)^{\alpha-2} < 0 \tag{10}$$

Thus, theoretically, according to equation 10, population characterized by an increase in physical capital stock per worker should decrease the rate of returns of physical capital stock. The outcomes provided by simulation exercises undertaken by Krueger and Ludwig (2007) on OECD countries seem validate the theoretical insights underlined in equations 8 and 10.

Aglietta, Chateau, Fayolle, Juillard, Le Caheux, Le Garrec, and Touzé (2007) undertake a similar analysis like Krueger and Ludwig (2007). For that purpose, they develop an international computable overlapping generations model of the world economy known as INGENUE model. Unlike to Krueger and Ludwig (2007) focusing only on OECD countries, INGENUE takes into account the main regions in the World including those non-affected by population aging composed principally by developing countries. Results obtained with INGENUE suggest that the increase in capital/labor ratio ($k_t$) could occur if and only if economy is closed. By considering both the regions affected and non-affected by population aging and by assuming that all regions evolve in open economy, the simulations outcomes provided by INGENUE exhibit an international capital flow - from regions non-affected by population aging to those affected by this demographic transition - able to annihilate the increase in capital/labor ratio and maintain the rate of returns of physical capital at its current level. A similar result was also obtained in an earlier version of INGENUE (Ingenue 2005).

The combination of three elements explains the capital flows from regions non-affected by population aging to those affected by this demographic transition. The first element is that aging process is not synchronous across regions in World. On one side, some developed countries composed mainly by European countries and Japan are experiencing the aging of their population. On the other side, some countries formed mainly by African and Asian countries are undergoing the increase in size of their working-age population. The difference in capital supply across countries resulting from this difference in times profiles of demographic changes explains the second element. Indeed, according to the life-cycle theory developed by Modigliani (1985), the capital supply, given by the aggregate saving and denoted by $S_t$, varies with population age-structure. More precisely, according to this author, during the life-cycle, young people borrow, mature-age people save and retired people dissave. It follows that in developing countries - due to the rise in size of mature-age population who save - the level of capital supply is high. Denote by $\overline{S_t}$ the capital supply from developing countries. At the opposite, in developed countries - due to the rise in size of retired population who dissave - the level of capital supply decreases. Denote by $\underline{S_t}$ the capital supply from developed countries. It appears that the difference in times profiles of demographic changes implies that $\overline{S_t} > \underline{S_t}$. On the capital market in each country, the capital supply $S_t$ is equal to physical capital stock $K_t$, namely $\overline{S_t} = \overline{K_t}$ and $\underline{S_t} = \underline{K_t}$. In other words, the physical capital stock should decrease in aging economy but should rise in countries non-affected by population aging. By combining $\overline{S_t} = \overline{K_t}$ and $\underline{S_t} = \underline{K_t}$ with the result underlined in equation 10, it appears that $\overline{S_t}$ implies low rate of returns of physical capital designated by $\check{u}_t$ and $\underline{S_t}$ involves high rate of returns of physical capital indicated by $\hat{u}_t$. This difference in rate of returns of physical capital between regions affected and non-affected by population aging explains the third element. Indeed, $\hat{u}_t > \check{u}_t$ incites savers in developing countries to invest in developed countries. Thus, by assuming a capital mobility between all regions in the World, $\hat{u}_t > \check{u}_t$ implies necessarily an international capital flow from regions non-affected by population aging to those affected by this demographic transition. All of these mechanisms are highlighted in INGENUE model (Ingenue 2005, Aglietta, Chateau, Fayolle, Juillard, Le Caheux, Le Garrec, and Touzé 2007).

Note that even if the life-cycle theory suggest that aggregate saving level should decrease in developed countries with population aging, the process describing the decrease in aggregate saving is not linear. Indeed, applying the theory developed by Modigliani (1985) on aging process in developed countries implies that after the baby boom the increase in size of mature-age population involves the rise in aggregate saving $S_t$ in a first stage. However, the decrease in size of mature-age population accompanying the aging process reduces the level of this aggregate saving in a second stage. As population aging involves the increase in size of people who dissave, this demographic change should decrease the level of aggregate saving. Thus, by assuming a strict equality between the aggregate saving and the physical capital stock in economy, by reducing the aggregate saving level, population aging should decrease the physical capital stock.

The main threat resulting from population aging remains until now the unsustainability of fiscal policy. Population aging should deteriorate significantly social protection budget and consequently the government budget. Indeed, the rise in size of population aged 65 and over is accompanied by an increase in retirement expenditures. For example, the share in GDP of retirement expenditures was equal to 7.8% in 1970 against 14% in 2015 in France (Conseil d'Orientation des Retraites 2015). Note that past increase in retirement expenditures in France is not only explained by population aging. During the past decades, French pension system became more generous and more retired people perceived pension benefit from Social Security than after the Second World War. That is why the retirement expenditures increased significantly during the last decades. However, nowadays only population aging determines the increase in pension spending. At the same time, the decrease in size of workforce reduces the size of population financing the retirement expenditures. The combination of increase in size of retired population and decrease in size of working-age population then deteriorates the pension system budget. In France, the pension system budget was balanced in 1970 but generates a deficit from 2008 on. The deficit of pension system represents 0.4% of GDP in 2015 and should remain at this level until 2020 according to Conseil d'Orientation des Retraites (2015).

After 2020, the budgetary balance of French pension system depends primarily on labor productivity evolution. Indeed, by assuming that the growth of labor productivity ranges between 2% and 1.5% per year after 2020, the budget of French pension system should be balanced after 2030 despite of population aging according to Conseil d'Orientation des Retraites (2015). At the opposite, by assuming a labor productivity growth below 1.5% per year after 2020, Conseil d'Orientation des Retraites (2015) forecasts an increase in deficit of French pension system until 2060. This deficit should be ranged between 0.5% and 1.5% of GDP in 2060 if labor productivity growth is equal to 1% per year. The forecast on the evolution of French pension budget illustrate how far the magnitude of negative effects of population aging on economic growth and fiscal sustainability depends primarily on the evolution of labor productivity in coming decades. The next question follows:

**Question 1** *How should labor productivity evolve in aging economy ?*

## Population aging and labor productivity

In economics, to determine the evolution of labor productivity, one studies the evolution of the marginal contribution of labor during the production process. By assuming that firm's technology is described by equation 1, the marginal contribution of labor is given by equation 2 describing the marginal productivity of labor. Moreover, the first order conditions of firm's problem involve that the marginal contribution of labor equalizes the wage rate according to equation 6. This result involves that

$$w_t L_t = (1-\alpha) \times A_t (K_t)^{\alpha} (L_t)^{1-\alpha} \tag{11}$$

and implies that firm's profit is maximized if labor productivity is equal to wage income. According to equation 11, theoretically, the evolution of wage income perceived by workforce should indicate the evolution of labor productivity. In other words, following the evolution of labor productivity through the evolution of labor income is possible if the equality between wage income and labor productivity occurs as indicated in equation 11. In neoclassical model, this equality always occurs if all markets in the economy operate in perfect competition.

However, the perfect competition condition is not always verified in all markets especially in labor market. In reality, the equality between labor income and labor productivity is not always relevant. Approximating the evolution of labor productivity through the evolution of wage income should provide misleading results. Moreover, labor productivity is not homogenous across age. Labor productivity increases with age between 25 and 50 years-old because during this period the worker has a physical capacity allowing him to acquire knowledge and experience enabling to improve gradually his productivity. After 50 years-old, the worker ages and in getting older he looses gradually all abilities allowing him to produce more like during his mature-age. That is why the productivity should decline after 50 years-old. Thus, studying the evolution of labor productivity implies to consider that (i) labor market operates with frictions and (ii) labor productivity evolves with age.

Hellerstein and Neumark (1995) develop an empirical method allowing to consider that (i) labor market operates with frictions and (ii) labor productivity evolves age. To assess labor productivity, they suggest to estimate the relationship described in equation 1. More precisely, they estimate the following equation:

$$lnY_t = lnA_t + \alpha ln(K_t) + (1-\alpha) ln(L_t) \tag{12}$$

by approximating $Y_t$ by output produced in each firm. To measure labor income, they suggest to measure the remuneration perceived by workforce. Hellerstein and Neumark (1995) execute then a separate estimation of labor productivity and labor income.

Gobel and Zwick (2012) exploit the empirical method developed by Hellerstein and Neumark (1995) to analyze the effect of population aging on labor productivity in German firms. More precisely, they verify if the increase in share of workers aged 50 and over in workforce in German firms reduces or not the productivity in these firms. For that purpose, they study the differences in age-productivity profiles between manufacturing and services sectors in Germany. Seven million employees working in more than 8,500 establishments compose their database. To estimate the age-productivity profiles, they assess the value-added per worker at each age and regress a similar equation to equation 12. Their empirical evidences suggest that labor productivity declines significantly in all sectors after 55 years-old. This result suggest that the increase in size of workforce aged 55 and over should induce the decrease in labor productivity in German firms. By estimating equation similar to equation 12, Lallemand and Rycx (2009) obtained a similar result by using data on Belgian firms into sectors with high and low Information and Communication Technology (referred to below as ICT) intensity. Like Hellerstein and Neumark (1995), Lallemand and Rycx (2009) approximate the labor productivity by the value-added per worker.

At the opposite, the empirical evidences provided by Aubert and Crépon (2006) suggest that the decline in productivity after 50 years-old is not significant. These authors obtain their result by analyzing the age-productivity profile in 70,000 French firms between 1994 and 2000. Like Gobel and Zwick (2012) and Lallemand and Rycx (2009), these authors regress an equation similar to equation 12 and estimate labor productivity by value-added per worker. More general, by regressing an equation similar to equation 12 and approximating labor productivity by value-added per worker, Daveri and Maliranta (2007) on Finnish data and van Ours and Stoeldraijer (2011) on Dutch data obtained similar empirical results to those of Aubert and Crépon (2006). By approximating labor productivity by sales per worker, Bertschek and Meyer (2009) on German data and Cardoso, Guimaraes, and Varejao (2011) on Portuguese data provide also empirical evidences suggesting a non-decrease in labor productivity after 50 years-old. Results obtained by Garibaldi, Martins, and Van Ours (2011) by studying the age-productivity profile in DaimlerChrysler group highlight also similar empirical evidences. To measure labor productivity, these authors consider absenteeism, sick leaves and the sum of errors per worker group in assembly line. All of these empirical results converge then to underline that increase in size of workforce aged 50 and over - accompanying population aging - should not reduce necessarily labor productivity in aging economy.

All of these studies fail to provide an empirical evidence on the significant decline of labor productivity after 50 years-old because this latter does not depend only on age. Labor productivity depends also on human capital defined by Becker (1964) as *a set of productive capacity acquired by an individual accumulation of general and specific knowledge, skills, etc.* Experience belongs to this set of productive capacity allowing to increase labor productivity. Note by $E_t$ the aggregate experience in economy such that $E_t = e_t \times L_t$ with $e_t$ the individual experience stock. By augmenting equation 1 by $e_t$, we have:

$$Y_t = A_t(K_t)^\alpha(e_t \times L_t)^{1-\alpha} \tag{13}$$

It follows that:

$$\frac{\partial^2 Y_t}{\partial e_t \partial L_t} = (1-\alpha)^2 A_t(k_t)^\alpha(e_t)^{-\alpha} > 0 \tag{14}$$

Equation 14 demonstrates that any increase in $e_t$ improves labor productivity. The insight behind this result is summarized by Arrow (1962) by indicating that by repeating the same type of action, individuals acquire experience and are thereafter able to improve their productivity. This is the *learning-by-doing process.*

In aging context, the *learning-by-doing process* could improve the workforce labor productivity. Indeed, population aging is determined partly by an increase in life expectancy. The rise in life expectancy should extend the life-time devoted to work. The expand in life-time devoted to work should allow to accumulate more experience. The additional experience resulting from increase in life expectancy should improve thereafter the workforce labor productivity. By linking this theoretical insight with the future evolution of life expectancy in France, one could think that the future increase in French longevity should increase the labor productivity through the experience channel. Malmberg, Lindh, and Halvarsson (2008) exploit for example this insight to explain the increase in labor productivity in Swedish mining and manufacturing industries between 1985 and 1996 in spite of workforce aging.

Education composes the second main component of human capital. Theoretical studies undertaken by Mincer (1958), Becker (1964), Nelson and Phelps (1966) and Ben-Porath (1967) demonstrate that higher educational level allows to upgrade significantly labor productivity. Indeed, indicate by $b_t$ the worker educational attainment. By augmenting equation 1 by $b_t$, we can write:

$$Y_t = A_t(K_t)^{\alpha}(b_t \times L_t)^{1-\alpha} \tag{15}$$

It follows that:

$$\frac{\partial^2 Y_t}{\partial b_t \partial L_t} = (1-\alpha)^2 A_t(k_t)^{\alpha}(b_t)^{-\alpha} > 0 \tag{16}$$

Equation 16 shows that higher educational attainment increases labor productivity. By regressing the logarithm of equation 15 and approximating $Y_t$ and $b_t$ by respectively GDP and years of education, this theoretical insight was validated empirically by some authors like Mankiw, Romer, and Weil (1992), Barro and Lee (1993), Bils and Klenow (2000), Barro (2013a).

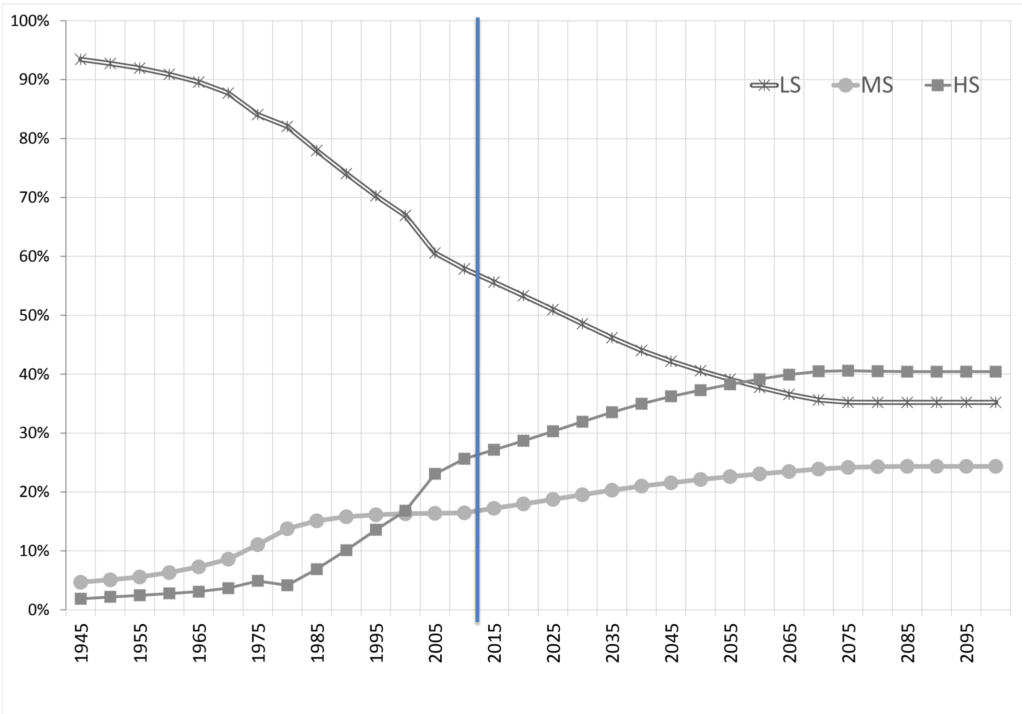
In France the educational attainment of population increases significantly during the last decades. According to French Population Census published in 2008, among population aged 60 in 2008, 66.8% has no diploma (low-skilled people), 13.5% obtained *baccalaureat*[3] and made at most two years' higher education (medium-skilled people), and 19.7% made more than two years' higher education (high-skilled people). At the opposite, among population aged 30 at the same year, 35.1% has no diploma, 22.1% obtained *baccalaureat* and made at most two years' higher education, and 42.8% made more than two years' higher education. By assuming no changes in skill structure of

[3] *Baccalauréat* is the French equivalent to Higher Leaving Certificate.

cohorts aged 30 after 2008, the rise of high-skilled young cohorts in age pyramid should improve significantly the skill structure of French population in the coming decades as illustrated in Figure 1. Thus, by linking the studies undertaken by Mankiw, Romer,

Figure 1: Skill structure of French population over time (% of total population)




and Weil (1992), Barro and Lee (1993), Bils and Klenow (2000), Barro (2013a) with the evolution of educational attainment in French population, one could think that the future changes in skill structure in France should affect positively the labor productivity of French workforce. Not considering the productivity gains resulting from this future rise in educational attainment in assessment of economic consequences of population aging could then provide misleading results. For example, Chojnicki and Docquier (2007) show that, by neglecting the effect of education on US economy, Gokhale, Page, and Sturrock (1999) over-estimate the generational imbalanced of U.S. fiscal policy by about 30.7%.

## Labor productivity and health status

Health forms the third main component of human capital. Its benefit effect on labor productivity was demonstrated by Grossman (1972) in its seminal paper. This author develops a model in which private health expenditures upgrade health status influencing positively the time allocated to work. More precisely, he shows that by making health expenditures, workers enhance their health status. Health improvement increases time devoted to work and allows thereafter to produce more.

To exhibit this positive effect of health status on the representative firm's production function, let $h_t$ the individual state of health. By augmenting equation 1 by $h_t$, we can write:

$$Y_t = A_t(K_t)^{\alpha}(h_t \times L_t)^{1-\alpha} \tag{17}$$

It follows that:

$$\frac{\partial^2 Y_t}{\partial h_t \partial L_t} = (1-\alpha)^2 A_t(k_t)^{\alpha}(h_t)^{-\alpha} > 0 \tag{18}$$

Equation 18 demonstrates that high level of $h_t$ is able to increases labor productivity and then the output obtained during the production process indicated by $Y_t$.

To verify the empirical relevance of theoretical result showed in equation 18, Bloom and Canning (2005) rearrange equation 17 to obtain the expression of output per worker. This latter is given by $y_t$ such that

$$y_t = A_t\,(k_t)^{\alpha}\,(h_t)^{1-\alpha} \tag{19}$$

Thereafter, Bloom and Canning (2005) approximate $y_t$ and $h_t$ by respectively GDP per capita and the adult survival rates. The survival rates are used to measure $h_t$ because these authors assume that high survival rates reflect a better health status. Based on this health indicator, they regress the logarithm of equation 19 by exploiting a panel database of 104 countries between 1960 and 1995. Their empirical results suggest that one percentage point increase in adult survival rates translates into a 2.8% increase in GDP per capita. Weil (2007) undertakes a similar study as Bloom and Canning

(2005). For that purpose, like Bloom and Canning (2005), he approximate $h_t$ by the adult survival rates. He regress also the logarithm of equation 19 by exploiting a panel database of 92 countries and obtain empirical evidences validating the result underlined in equation 18. More precisely, his results suggest that one percentage point increase in adult survival rates improves the GDP per capita by 6.53%.

To check the empirical relevance of equation 19, Bloom, Canning, and Sevilla (2004) approximate $h_t$ with life expectancy. By assessing $h_t$ with life expectancy, these authors assume that higher life expectancy reflects a better health as this latter allows to expand the lifetime. Bloom, Canning, and Sevilla (2004) undertake their empirical analysis by exploiting a panel data composed by 104 countries between 1960 and 1990 and by regressing the logarithm of equation 19. Their result suggest that one-year improvement in population's life expectancy contributes to a 4% increase in $y_t$. Like Bloom, Canning, and Sevilla (2004), Aghion, Howitt, and Murtin (2011) estimate $h_t$ with life expectancy. They regress the logarithm of equation 19 by using a panel data formed by 96 countries between 1960 and 2000. They estimate that one percentage point increase in life expectancy improves $y_t$ by 2%. By adopting a similar methodology, Barro (2013b) estimate that a rise in life expectancy from 50 to 70 years would raise the GDP per capita rate by 1.4 percentage points per year. This authors uses a panel data composed by roughly 100 countries observed from 1960 to 1990.

In France, the life expectancy should rise significantly in the coming decades. As indicated in Table 1, the life expectancy at 60 years-old in France should increase from 24.8 years in 2010 to 30.4 years in 2060. French life expectancy should extend by about 7 years in the five coming decades. By assuming like Bloom, Canning, and Sevilla (2004), Aghion, Howitt, and Murtin (2011) and Barro (2013b) that life expectancy reflects the health status, the future rise in French life expectancy should traduce an health improvement of French population. Moreover, by referring on theoretical insight underlined in equation 18, this future health improvement of French population should enhance labor productivity of workforce. Thus, by linking the results of studies undertaken by Bloom, Canning, and Sevilla (2004), Aghion, Howitt, and Murtin (2011) and Barro (2013b) with the future evolution of French life expectancy, the following questions emerge:

**Question 2** *Could the future increase in French life expectancy generate potential productivity gains ?*

**Question 3** *Could potential productivity gains resulting from the future rise in French life expectancy annihilate the expected negative effects of French population aging ?*

## The potential economic benefits of increase in health spending

During the last decades, the increase in life expectancy of French population was allowed by health condition improvement in France. One factor determining this health condition improvement is health spending. Indeed, by retaining the life expectancy as health indicator, it appears that increase in life expectancy - traducing an health improvement - follows the increase in health spending in France. In 1970, the share in GDP of total health spending in France represented 6% against 10.2% in 2010 (see Table 3). According to official forecasts undertaken by French High Council for the Future of Health Insurance[4] (referred to below as HCAAM), this positive trend in evolution of French health spending should continue to occur in the coming decades. Total health spending in France should attain 12.7% of GDP in 2040 and 13,1% in 2060 (HCAAM 2013).

On one side, this future increase in total health spending could amplify the negative effect of population aging on French government budget. Indeed, as this increase in total health spending is mainly driven by the increase in public health expenditures, as indicated in Table 3, the future increase in public health spending should deteriorate the budget of public health insurance. According to HCAAM (2013), the share in GDP of public health insurance deficit could attain 2.4% in 2060 against 0.3% in 2014. Note that even if health spending rise with age as illustrated in Figure 2, French population aging explains only 0.5 percentage point of increase in total health spending until 2040 according to estimation obtained by HCAAM (2013). According to HCAAM, the two

[4]Haut Conseil pour l'Avenir de l'Assurance Maladie

Table 3: Health spending in France (1970 - 2060)

| | Share in GDP of | | | |
|---|---|---|---|---|
| Year | OOPE on health (%) | Private health spending (%) | Public health spending (%) | Total health spending (%) |
| 1970 | 0.82 | 1.19 | 4.07 | 6.08 |
| 1980 | 0.73 | 1.09 | 5.23 | 7.05 |
| 1990 | 1.11 | 1.59 | 5.79 | 8.48 |
| 2000 | 1.12 | 2.27 | 7.32 | 10.71 |
| 2010 | 0.80 | 1.72 | 7.72 | 10.24 |
| 2020 | - | - | 8.70 | 11.00 |
| 2030 | - | - | 9.40 | 11.90 |
| 2040 | - | - | 10.10 | 12.70 |
| 2050 | - | - | 10.25 | 12.90 |
| 2060 | - | - | 10.40 | 13.10 |

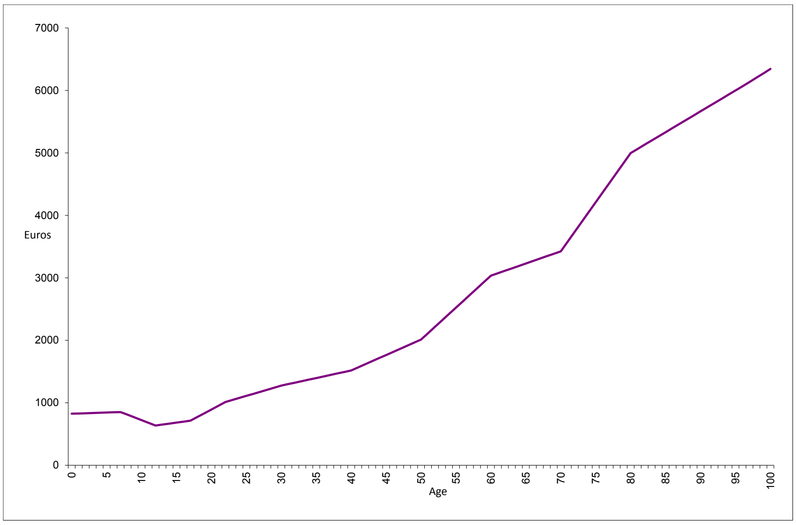
Sources: - HCAAM
- http://www.oecd.org/fr/sante/base-donnees-sante.htm

mains factor explaining the future increase in health spending in France are (i) the economic growth and (ii) the faster growth of individual health spending compared to growth of GDP per capita. Between 2015 and 2024, the contribution of the first and second factors in health spending growth are estimated at respectively 2.2 and 0.4 percentage point of increase in total health spending. Between 2025 and 2040, those contributions should represent respectively 1.7 and 0.22 percentage point of increase in total health spending.

On the other side, some theoretical studies highlight the potential benefit effects resulting from increase in public health spending. By assuming an explicit positive link between public health spending and life expectancy, Aisa and Pueyo (2004) show that higher public health spending allow to expand significantly the life expectancy. Higher life expectancy incites individuals to increase their saving. Higher saving increases the physical capital stock, labor productivity and then the economic growth. Chakraborty (2004) find also a similar result by exploiting the same mechanism. Bhattacharya and Qiao (2007) show that the increase in public health spending is able to improve the returns to private health spending on longevity and generate higher life expectancy and then economic growth like in Aisa and Pueyo (2004) and Chakraborty (2004). According to Blackburn and Cipriani (2002a), higher life expectancy allows the occurrence of high steady-state equilibrium in which life expectancy and human capital are higher and are able to generate more economic growth also.

Figure 2: Total health spending profile by age (in euros)




Source: Enquête Santé Protection Sociale (ESPS) 2010 and authors' calculation

Fanti and Gori (2011) indicate that public health spending are able to improve the efficiency of labor supplied by old-age workers. More precisely, they assume that relationship between public health spending $m_t$ at period $t$ and old worker health status $h_{t+1}$ at the next period is given by:

$$h_{t+1} = \frac{h_0 + h_1 \triangle (m_t)^\delta}{1 + \triangle (m_t)^\delta} \tag{20}$$

In equation 20, $h_0$ indicates the natural health level of old worker. $h_1$ and $\triangle$ designate scale parameters determining the efficiency of $m_t$ with $\delta$ the rate of returns of public health spending. According to equation 20, as:

$$\frac{\partial h_{t+1}}{\partial m_t} = \frac{\delta \Delta (m_t)^{\delta - 1}(h_1 - h_0)}{(1 + \Delta (m_t)^\delta)^2} > 0$$

any increase in $m_t$ upgrades $h_{t+1}$. They assume thereafter that labor efficiency of old worker is given by $h_{t+1}$. Thus, due to the functional form retained by Fanti and Gori (2011), any increase in $m_t$ improves the efficiency of labor supplied by old-worker. By assuming, for illustrative convenience, that only old-workers supply an inelastic labor in economy at period $t+1$, and by augmenting equation 19 by $h_{t+1}$ such that $h_{t+1}$ is defined by equation 20, the following equation is obtained:

$$y_{t+1} = A_{t+1}\left(k_{t+1}\right)^{\alpha}\left(\frac{h_0 + h_1\triangle(m_t)^{\delta}}{1+\triangle(m_t)^{\delta}}\right)^{1-\alpha} \tag{21}$$

Equation 21 highlights the positive effect of health spending on output per worker and this positive effect occurs through the labor productivity channel in Fanti and Gori (2011). These authors demonstrate an explicit link between health spending and output per capita through equation 21.

By linking the theoretical results obtained by Aisa and Pueyo (2004), Chakraborty (2004), Bhattacharya and Qiao (2007), Blackburn and Cipriani (2002a) and Fanti and Gori (2011), with the future increase in health spending in France as indicated in Table 3, the following questions emerge:

**Question 4** *Could the future increase in health spending generate potential economic growth in France?*

**Question 5** *Could the future increase in health expenditures improve labor productivity of old-worker as indicated by Fanti and Gori (2011)?*

**Question 6** *Is there any other channel through which the future increase in health spending can affect positively labor productivity?*

**Question 7** *Could the potential economic growth and labor productivity gains - resulting from the future increase in health spending in France - offset the expected negative effects of French population aging?*

Among the positive effects of health spending, Hall and Jones (2007) demonstrates also that health spending are able to improve the welfare. These authors assume that the relationship between health expenditure and health status of individual aged $a$ at period $t$ is given by $h_{a,t}$ such that:

$$h_{a,t} = A_a\left(z_t m_{a,t} \omega_t\right)_a^{\theta} \tag{22}$$

$A_a$ and $\theta_a$ designate parameters depending on age. $z_t$ indicates the efficiency of health spending $m_{a,t}$. $\omega_t$ captures the effect of all other determinants of health status. Unlike to Fanti and Gori (2011) who focus on public health spending, Hall and Jones (2007) only consider private health spending. Contrariwise to Fanti and Gori (2011) who assume that health spending at period $t$ affect health status at the next period, Hall and Jones (2007) assume an instantaneous effect of health expenditures on health status. These authors introduce also an explicit link between $m_{a,t}$ and the mortality rates $x_{a,t}$ as:

$$x_{a,t} = \frac{1}{A_a \left(z_t m_{a,t} \omega_t\right)_a^{\theta}} \tag{23}$$

By assuming that the individual intertemporal utility function is given by $U$ such that:

$$U(c,h) = \int_0^{\infty} e^{-(1/h)t} u(c,h) dt \tag{24}$$

Hall and Jones (2007) show that by enhancing health status, health expenditures improve instantaneous wellbeing as well as consumption $c$. They demonstrate also that as better health status diminishes the mortality rates, lower mortality rates increase the intertemporal well-being by having additional periods of utility. According to Hall and Jones (2007), health spending are then able to improve the individual welfare by enhancing the instantaneous utility and by offering additional periods of utility. Thus, by linking the theoretical results obtained by Hall and Jones (2007), with the future increase in health spending in France as indicated in Table 3, the following questions emerge:

**Question 8** *Could the future increase in health spending in France enhance the welfare of French population?*

## The aim of this dissertation

The aim of this dissertation is to answer Questions 1 to 8. For that purpose, firstly, we explore if there is any other channel through which the future increase in health spending can affect positively labor productivity. Secondly, we explore if the future increase in French life expectancy generate potential productivity gains. Third, we verify, if potential productivity gains resulting from the future rise in French life expectancy annihilate the expected negative effects of French population aging. Fifth, we study if the future increase in health expenditures improve labor productivity. Sixth, we verify if the potential economic growth and labor productivity gains - resulting from the future increase in health spending in France - offset the expected negative effects of French population aging.

More precisely, in the first part of this dissertation (Part I), we answer Question 6 asking if there is any other channel through which the future increase in health spending can affect positively labor productivity. Based on the relationship between private health spending, health status and welfare established by Hall and Jones (2007) (see equations 22 and 24), the first channel that we explore is the effect of a potential positive externality resulting from health expenditures - intended to enhance the quality of life - on labor productivity. We argue in Chapter 1 that by making health expenditures to enhance its welfare, an individual generates also a positive externality affecting labor productivity in economy. To highlight the mechanism behind this insight we develop, in Chapter 1, a two-period Overlapping Generations model (referred to below as OLG model) where two types of households coexist: the ones with poor health and those with good health. Like in Hall and Jones (2007), each type of household undertakes health expenditures to improve its quality of life. However, we assume that rate of returns of health spending on health improvement differs from one type of household to another. We specify that healthy households have lower rate of returns than those with poor health. Based on this specification, we assume that as healthy households have good health, by spending on health, they generate at the same time a positive externality. Consequently, households with poor health are not able to generate a positive externality. This externality is assumed to determine the efficiency of labor supplied by all young households. Thus, higher are health expenditures, higher is the positive externality, higher is labor efficiency and then higher is labor productivity.

Through this mechanism, we demonstrate that health spending - devoted to improve quality of life - are also able to enhance labor productivity. This channel contrasts with the traditional one assuming an explicit direct link between health expenditures and labor productivity like in Fanti and Gori (2011). In addition, this theoretical result provides an additional support to Hall and Jones (2007) findings that suggest to increase significantly the weight of health spending in economy to improve the social welfare. Indeed, by linking our theoretical result with the one highlighted by Hall and Jones (2007), it seems that devoting more resources to health expenditures in order to improve the intertemporal utility as suggested by Hall and Jones (2007) could be also an efficient way to increase resources in economy because these health spending enhance in parallel labor productivity and then wealth production.

The second channel explored in Chapter 2 is the potential positive effect of out-of-pocket expenditure on health on elderly workers labor productivity. Out-of-pocket expenditure on health is the part of private health spending non-reimbursed by private health insurance. We focus on this part of health spending because most of studies investigating the effect of health spending on labor productivity undertake their analyze by considering public and private health spending, excluding out-of-pocket expenditure on health (Aisa and Pueyo (2004), Chakraborty (2004), Bhattacharya and Qiao (2007), Fanti and Gori (2011) and Gori and Sodini (2011)). However, as indicated in Table 3, the share in GDP of public health spending is high. Increasing public health expenditures to improve labor productivity could then threaten the sustainability of French fiscal policy. At the opposite, in France, the share in GDP of out-of-pocket expenditure on health attain only 0.8% in 2010. The aim of Chapter 2 is then to check if it is possible to enhance labor productivity by increasing total health spending without rising health expenditures reimbursed by public and private health insurance.

For that purpose, we develop a general equilibrium model with two overlapping generations in which workers make investment in health during their prime-age in order to enhance their labor efficiency during old-age. Out-of-pocket expenditure on health indicate the amount devoted to this investment in health. Like Fanti and Gori (2011), we assume that health spending at period $t$ affect labor efficiency at period $t+1$. Unlike to Fanti and Gori (2011) considering public health spending, we focus on out-of-pocket expenditure on health. Moreover, unlike to Fanti and Gori (2011) who define the relationship between health spending and health status by equation 20, we characterize this relationship by equation 22 like in Hall and Jones (2007). However, for analytical convenience, unlike to Hall and Jones (2007), we neglect the effect of health spending on welfare. By adopting these specification, the model predicts that increasing the out-of-pocket on health during prime-age is one way to enhance the elderly workers productivity.

Note that instead of analyzing the health spending effect on young workers productivity like in Chapter 1, we devote Chapter 2 to study the health spending effect on old workers productivity. Indeed, given the current trend towards population ageing, the share of old workers in workforce should increase. Enhancing old workers labor efficiency could then generate some productivity gains able to annihilate the expected negative consequences of population aging. Fanti and Gori (2011) demonstrate this insight by focusing on public health spending, we develop this insight by considering the out-of-pocket expenditure on health.

To check the empirical relevance of prediction provided by model developed in Chapter 2, we exploit the general equilibrium framework of our OLG model. Indeed, our OLG model exhibits a microfoundation of the empirical model allowing to check empirically if increasing the out-of-pocket expenditure on health during prime-age is one way to enhance the elderly workers productivity. Survey of Health, Ageing and Retirement in Europe (referred to below as SHARE) database is exploited to undertake this empirical analysis. However, econometric results suggest that the positive effect of out-of-pocket expenditure on health on elderly workers productivity is limited. In other words, it seems that the productivity gains obtained by elderly workers by rising their out-of-pocket expenditure on health during prime-age should not be significant.

After answering Question 6, we devote the second part of this dissertation (Part II) to answer Questions 2 to 5 and Questions 7 to 8. More precisely, in Chapter 3, we investigate, if the future increase in French life expectancy is able to generate some potential productivity gains as suggested in studies undertaken by Bloom, Canning, and Sevilla (2004), Aghion, Howitt, and Murtin (2011) and Barro (2013b). For that purpose, we develop a Generational Accounting Model applied to the French economy. Generational accounting is a forecasting method developed by Auerbach, Gokhale, and Kotlikoff (1991) allowing to estimate the intergenerational fiscal burdens generated by a given fiscal policy. To the best of our knowledge, the last generational accounting model applied to French economy was undertaken by Chojnicki (2013). By exploiting the generational accounting framework developed by Chojnicki (2013), we update then the measure on sustainability of French fiscal policy by assuming that all individual taxes and transfers grow at the same pace with labor productivity. It appears that fiscal burden induced by French population aging should represent 129% of 2010 GDP.

However, following the traditional method of generational accounting model, Chojnicki (2013) assumes that labor productivity growth is constant over time and neglects the effects of educational attainment and health improvement on labor productivity. To give up this assumption, we develop a revisited generational accounting model in which labor productivity growth is partially explained by skill-level and health enhancement of French population in the spirit of equation 19. Following Bloom and Canning (2005) and Weil (2007), we approximate the health improvement by the evolution of survival rates. The results obtained with this revisited generational accounting model applied to French economy suggest that the future health improvement of French population should reduce by 16% the fiscal burden induced by French population aging. In other words, the future health improvement of French population allowing the increase in life expectancy should generate productivity gains. Unfortunately, these productivity gains should not be enough to annihilate the fiscal burden resulting from population aging. The productivity gains resulting from the future changes in skill structure of French population should decrease the fiscal burden by 63%. Finally, we estimate that the future change in skill structure and health improvement of French population should reduce by 79% the fiscal burden induced by French population aging. However, these productivity gains should not be also able to annihilate the negative effects of French population aging.

Results provided by our generational accounting model must be taken with cautious. Indeed, general accounting model is a partial equilibrium model. Consequently, its framework is not able to consider all health improvement impacts on French economy. General accounting model does not take into account all interdependencies between demography and economy and neglect also the economic effects of future increase in health spending. To consider the interdependencies between demography and economy and to assess the potential benefits resulting from the future increase in health spending, we develop a general equilibrium model in Chapter 4.

The general equilibrium model developed in Chapter 4 supplies an unified framework to overcome the caveats of generational accounting model. The unified framework considers the relationship between health spending, health status and intertemporal welfare established by Hall and Jones (2007). Following these authors, the general equilibrium model takes into account the effect of health spending on demographic bloc as illustrated in equation 23. Finally, in the same line with Bloom and Canning (2005), Weil (2007), Aghion, Howitt, and Murtin (2011) and Barro (2013b), the unified framework considers also the effects of health status on labor productivity. This general equilibrium model is thereafter applied to the French economy to answers Question 4, 7 and 8.

Results obtained with the general equilibrium model applied to the French economy reveal that the potential life gains resulting from the future increase in health spending are not substantial. In average, these life gains should not exceed 2 months in long term. Moreover, the potential productivity gains allowed by health improvement should not be enough to generate more potential economic growth. The GDP per capita should improve by only 1 percentage point per period in the best case if total health spending grows in future. This result confirms then the previous one obtained in Chapter 3.

# Part I

# Exploring two potential channels through which health spending can affect labor productivity

In this part, by exploring two alternative channels, we investigate how the increase in health spending could improve labor productivity. The first channel analyzed in Chapter 1 refers on the positive externality resulting from health spending intended to enhance the quality of life and enhancing labor efficiency. We explore this channel because economic literature identifies three main motives to make health expenditures. The first motive is to improve labor efficiency as indicated in Grossman (1972), Fanti and Gori (2011), Gori and Sodini (2011), etc. The second motive is to extend the life expectancy as suggested by Aisa and Pueyo (2004), Chakraborty (2004), Bhattacharya and Qiao (2007), etc. Finally, the third motive is to enhance the wellbeing as indicated in (Hall and Jones 2007).

By assuming an explicit link between health spending and labor efficiency, the first motive highlights the positive effect of health expenditures on labor productivity. The second motive exhibits also the positive effect of health spending on labor productivity by showing that health expenditures increase longevity, aggregate saving, physical capital stock and at least labor productivity as indicated in General Introduction. By contrast, the third motive does not consider any link between health spending intended to improve wellbeing and labor productivity. We argue then in Chapter 1 that this third motive to expend on health can also improve labor productivity. To demonstrate that health spending devoted to enhance wellbeing are able to improve labor productivity, we develop an OLG model in which health expenditure - allowing to enhance welfare - generate a positive externality. This positive externality affects thereafter labor efficiency and then labor productivity. Thus, we show that the third motive to make health expenditures allows to enhance labor productivity.

Even if the three motives to expend on health allow to improve labor productivity, health spending in European countries are mainly composed by public health spending. Since the mid-1990s, the share of public health spending exceeds 50% of total expenditures on health in European countries (see Table 4). This share rises from 69.1% in 1960 to 76.5% in 2010 on average in EU27 (OECD). This share is higher than the share of public health spending in total health expenditures observed in OECD countries during the same period (60.5% in 1960 and 72.8% in 2010 on average).

Table 4: Share of public expenditure on health in total health spending in selected countries (in %)

| | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 |
|---|---|---|---|---|---|---|
| Australia | 50.3 | .. | 62.6 | 66.2 | 66.8 | 67.8 |
| Austria | 69.4 | 63.0 | 68.8 | 72.9 | 75.6 | 75.5 |
| Canada | 42.6 | 69.9 | 75.6 | 74.5 | 70.4 | 70.8 |
| Denmark | .. | .. | 87.8 | 82.7 | 83.9 | 85.1 |
| Finland | 54.1 | 73.8 | 79.0 | 80.9 | 71.3 | 74.2 |
| France | 62.4 | 75.5 | 80.1 | 76.6 | 79.4 | 77.5 |
| Germany | .. | 72.8 | 78.7 | 76.2 | 79.5 | 76.7 |
| Japan | 60.4 | 69.8 | 71.3 | 77.6 | 80.8 | 82.1 |
| Luxembourg | .. | 88.9 | 92.8 | 93.1 | 85.1 | 85.9 |
| Norway | 77.8 | 91.6 | 85.1 | 82.8 | 82.5 | 84.7 |
| Sweden | .. | 86.0 | 92.5 | 89.9 | 84.9 | 81.5 |
| United Kingdom | 85.2 | 87.0 | 89.4 | 83.6 | 79.1 | 84.0 |
| United States | 22.9 | 36.1 | 41.0 | 39.4 | 43.0 | 47.4 |
| OECD (in average) | 60.5 | 72.4 | 73.1 | 72.8 | 71.5 | 72.8 |
| EU27 (in average) | 69.1 | 75.5 | 80.3 | 79.3 | 76.5 | 76.5 |

Source: http://stats.oecd.org/

However, as indicated in General Introduction, the share of public health spending in total health expenditures should continue to growth in the coming decades with population aging. Most of European countries try then to stabilize the evolution of public health spending over time. Unfortunately, by adopting this policy, European countries could not be able to enjoy the potential benefits resulting from the increase in public health spending demonstrated by Aisa and Pueyo (2004), Fanti and Gori (2011) and Gori and Sodini (2011). Fortunately, health expenditures in these countries are also composed of private health spending reimbursed by private health insurance and out-of-pocket expenditure on health. Thus, we investigate in Chapter 2 the ability of out-of-pocket expenditure on health to improve labor productivity.

This choice is motivated by the particular features of health spending reimbursed by private health insurance (this part of health spending is referred to below as HSR). All parameters determining the individual amount of HSR are established by private health insurance. In other words, the HSR's amount is not chosen at the individual level but defined by health insurance. It involves that each individual is not able to determine the amount of HSR which could improve his health status and therefore his labor productivity. At the opposite, out-of-pocket expenditure on health (referred to below as OOPE on health) can be assimilated as an individual health spending. Making OOPE on health is more or less the result of a private choice between spending more or not on health than the level established by health insurance. Even if, in general, agents make OOPE on health because the reimbursement amount established by health insurance is not always enough high, that is why OOPE on health is most of the time assimilated to a constraint amount composing health spending, individuals are able to choose between engaging or not this constraint amount. That is why OOPE on health can be assimilated to an individual private health spending. Through the OOPE on health, each individual is able to determine the individual private health spending which could improve his productivity like public health spending. Thus, we verify theoretically and empirically in Chapter 2 if the OOPE on health is an other determinant of labor productivity.

# Chapter 1

# Externality from health spending: a new channel to improve labor productivity

To demonstrate the occurrence of a positive externality resulting from health spending intended to improve the quality of health, we develop in Section 1.1 a two-period OLG model in which two types of households coexist: the ones with poor health and those with good health. Like in Hall and Jones (2007), each type of household makes health expenditures to improve its quality of life. We specify that returns to health spending as quality of health differs from one type of household to another. More precisely, we characterize households with poor health by lower marginal increase in health improvement than those with good health. The motive of this specification is demonstrated in Section 1.1.

We assume that the quality of health determines the ability of each household to generate a positive externality from health spending. We specify that the high quality of health provides an ability to healthy households to generate this positive externality. Consequently, unhealthy households are not able to generate a positive externality by making health spending. The positive externality drives thereafter the evolution of the size of young healthy households over time. By exploiting this specification and following Muysken, Yetkiner, and Ziesemer (2003), we approximate the overall health in economy by the share of young healthy households in young generation. The overall health depends then on a positive externality generated by health spending from healthy households. The overall health is thereafter assumed to determine the efficiency of labor supplied by young households whatever their types. By liking all of these mechanisms, we show how health spending devoted to improve the quality of life enhance also labor productivity.

We explain in Section 1.2 that health spending intended to enhance quality of life are able to increase labor productivity because these expenditures allow an intergenerational transmission of health. Intergenerational transmission of health is a well-known process highlighted by epidemiologic academic research (Ben-shlomo and Kuh 2002). It describes the fact that health status of previous generations drives the state of health of contemporary and future generations. In our model, intergenerational transmission of health occurs through the positive externality generated by health spending intended to improve quality of life. Indeed, this type of health expenditures reflect households' preferences to quality of life. The positive externality resulting from these expenditures then permits an intergenerational transmission of life quality between each generation. As this positive externality affects positively the efficiency of labor supply, we demonstrate through our theoretical model that health expenditures devoted to enhance quality of life are also able to improve productivity of active people also.

By exploring the insight of intergenerational transmission of health, our result reinforces the one obtained by Grossman (1972) on the benefit effect of health spending on labor productivity. As mentioned earlier, this benefit effect was also demonstrated by Fanti and Gori (2011) and Gori and Sodini (2011). However, unlike to us, these authors do not study the ability of health spending to generate a positive externality. Moreover, contrariwise to Fanti and Gori (2011) and Gori and Sodini (2011), we neglect public health spending and focus our analysis on private health spending. Nonetheless, by showing the benefit effect of public health expenditures on productivity, Fanti and Gori (2011) and Gori and Sodini (2011) warn on the ability of public health spending to generate an endogenous fluctuation. Could then the private health spending intended to improve quality of life also generate endogenous fluctuation ? To explore this issue, we determine in Section 1.3 the dynamical system characterizing the intertemporal general equilibrium of our model. Local stability analysis of dynamical system reveals in Section 1.4 that externality resulting from private health spending is not able to generate an endogenous fluctuation. In other words, the dynamical system always converges to an unique non-trivial steady-state in long run.

We also find that in decentralized economy the non-trivial steady-state is characterized by a difference in trade-off between health spending and consumption between healthy and unhealthy households. This difference in trade-off is mainly explained by the difference in returns to health spending as quality of life between the two types of households. It seems that decentralized allocation fails to allocate the same amount in health expenditures and consumption to each type of household. Is it also the case in planned economy ? To answer this question, we compare decentralized allocation with a planned one at the non-trivial steady-state in Section 1.5. Thus, we show that there is a range of configuration in which planned allocation is better than decentralized one for each type of household whatever its generation.

To sum up, this chapter is organized as follows. In Section 1.1, we present the model. In Section 1.2, we discuss on the role of intergenerational transmission of health in our model. We characterize the model's intertemporal general equilibrium in Section 1.3. We analyze the local dynamics around the steady state in Section 1.4. The model long run social optimum solution is described in Section 1.5. And we conclude with Section 1.6.

## 1.1 The model

### 1.1.1 Environment

Let's consider a two-period OLG model *à la Diamond*. Time is discret and two cohorts, worker generation and retired one, coexist at each period. Size of worker and retired generations are given respectively by $N_{t+1}$ and $N_t$ such that:

$$N_{t+1} = (1+n)\,N_t \tag{1.1}$$

with $n > 0$ the population growth rate.

Each generation is composed by households of type $l$ and households of type $h$. In the same line with Hall and Jones (2007), household of type $i \in \{l, h\}$ born at period $t$ is able to enhance its quality of life by improving its health status $x_{i,t}^t$. For that purpose, household of type $i \in \{l, h\}$ spends $m_{i,t}^t$ on health at the same period. Following Hall and Jones (2007), we assume that the relationship between $x_{i,t}^t$ and $m_{i,t}^t$ is described by:

$$x_{i,t}^t = \left(m_{i,t}^t\right)^{\gamma_i} \text{ with } i \in \{l; h\} \tag{1.2}$$

and $\gamma_i \in \,]0,1[$ the rate of returns of $m_{i,t}^t$ on $x_{i,t}^t$. The next proposition follows.

**Proposition 1** *Households of type $l$ are characterized by high $\gamma$, and compose households with poor health. Households of type $h$ are characterized by low $\gamma$, and form households with good health. Healthy household differs then from unhealthy one with respect to its level of $\gamma$ such that $0 < \gamma_h < \gamma_l < 1$.*

**Proof 1** $x_{i,t}^t = \left(m_{i,t}^t\right)^{\gamma_i}$ *implies that the marginal increase in health improvement is given by:*

$$\frac{\partial^2 x_{i,t}^t}{\partial\left(m_{i,t}^t\right)^2} = -\gamma_i\left(1-\gamma_i\right)\left(m_{i,t}^t\right)^{\gamma_i - 2}$$

*Thereafter, it is obvious to assume that healthy households are characterized by higher marginal increase in health improvement than unhealthy one. This specification involves* *that, if healthy and unhealthy households, whatever their generation, spend the same amount on health, namely, $m_h = m_l = m$, then:*

$$\frac{\partial^2 x_h}{\partial (m)^2} > \frac{\partial^2 x_l}{\partial (m)^2} \Leftrightarrow -\gamma_h (1-\gamma_h)(m)^{-(2-\gamma_h)} > -\gamma_l (1-\gamma_l)(m_l)^{-(2-\gamma_l)}$$

*However, this condition is verified if and only if $\gamma_l > \gamma_h$. Indeed, $\gamma_l > \gamma_h$ implies that $-\gamma_l < -\gamma_h$ and $1-\gamma_l < 1-\gamma_h$. By combining those previous inequalities, we deduce that $\gamma_l > \gamma_h$ involves $\gamma_l (1-\gamma_l) > \gamma_h (1-\gamma_h)$. Moreover, $\gamma_l > \gamma_h$ implies that $m^{-(2-\gamma_l)} > m^{-(2-\gamma_h)}$. By combining all of previous inequalities, $\gamma_l > \gamma_h$ involves then that $\gamma_l (1-\gamma_l) m^{-(2-\gamma_l)} > \gamma_h (1-\gamma_h) m^{-(2-\gamma_h)}$. It follows that $\gamma_l > \gamma_h$ implies $-\gamma_l (1-\gamma_l) m^{-(2-\gamma_l)} < -\gamma_h (1-\gamma_h) m^{-(2-\gamma_h)}$. Thus, if $\gamma_l > \gamma_h$ then*

$$\frac{\partial^2 x_h}{\partial (m)^2} > \frac{\partial^2 x_l}{\partial (m)^2}$$

*That's why healthy households are characterized by lower $\gamma$ than unhealthy households.*

According to Proposition 1, as the marginal increase in health improvement obtained by households of type $l$ by spending $m_l$ is always lower than the marginal increase in health improvement obtained by household of type $h$ by spending $m_h$, households of type $l$ have poor health. At the opposite, households of type $h$ have good health because the marginal increase in health improvement generated by $m_h$ exceeds always the marginal increase in health improvement obtained by households of type $l$ by spending $m_l$. In other words, to obtain the same level in health improvement, unhealthy households must spend more on health than households with good health. Healthy households can at the opposite obtain better and greater health improvement than households with poor health by expending less on health than households of type $l$. Thus, households of types $l$ and $h$ are qualified respectively as unhealthy and healthy because $0 < \gamma_h < \gamma_l < 1$. It involves that the type of each household does not depend on its health expenditure but relies on $\gamma_i$ which is given exogenously at its birth. In other words, health spending are not able to change the type of each household as the trait $i \in \{l, h\}$ is taken once-and-for-all.

**Corollary 1** *The elasticity of health status with respect to a variation of health spending of household of type i is given by:*

$$\varepsilon_\gamma^i \equiv \frac{\partial x_{i,t}^t}{x_{i,t}^t} \times \frac{m_{i,t}^t}{\partial m_{i,t}^t} = \gamma_i > 0$$

*such that* $\varepsilon_\gamma^L > \varepsilon_\gamma^H$.

**Proof 2** *As* $0 < \gamma_h < \gamma_l < 1$, $\varepsilon_\gamma^L > \varepsilon_\gamma^H$.

Thus, even if unhealthy households must spend more on health than healthy households (see Proposition 1), according to Corollary 1, any increase in health expenditures is accompanied by a greater health improvement whatever the type of household. However, as $0 < \gamma_h < \gamma_l < 1$, the gross increase in health improvement after an expenditure on health is higher for unhealthy households than for healthy ones. In addition, as indicated in Proposition 1, higher is the quality of life of unhealthy households, lower is the marginal increase in health improvement obtained by unhealthy households.

Distribution of healthy and unhealthy households in initial generation ($N_0$) is given exogenously at the initial period through a biological process. The size of households of type $h$ and $l$ in young generation at period $t$ are indicated respectively by $N_t^h$ and $N_t^l$ such that:

$$N_t = N_t^h + N_t^l \tag{1.3}$$

Assume that the evolution of $N_t^h$ over time is driven by a positive externality generated by health spending of young households of type $h$. More precisely, in the same spirit with Muysken, Yetkiner, and Ziesemer (2003)[1], suppose that the dynamic law of $N_t^h$ follows:

$$N_{t+1}^h = \vartheta_t \times \left(m_{h,t}^t \times N_t^h\right)^\theta \times \left(N_t^h\right)^{1-\theta} + (1-\nu)\, N_t^h \tag{1.4}$$

$\left(m_{h,t}^t \times N_t^h\right)^\theta \times \left(N_t^h\right)^{1-\theta}$ indicates the positive externality production function. $\theta \in ]0;1[$ reflects the state of externality's technology. $\vartheta_t > 1$ represents a non-constant

[1]Contrariwise to us, Muysken, Yetkiner, and Ziesemer (2003) assume that there is an unique representative agent in economy. These authors don't make then any difference between young and old generations nor between healthy and unhealthy households.

variable indicating the aggregate health spending efficiency. $\nu \in ]0,1[$ provides the rate at which the stock of healthy people decreases between two periods. More precisely, $\nu \in ]0,1[$ describes an exogenous biological process inducing a depreciation of $N_t^h$ over time. As a matter of fact, $\nu \in ]0,1[$ depends negatively on sanitary environment in economy like air quality, disease prevalence, pollution, etc. We also suppose that private health spending have no influence on $\nu$. This assumption implies that health expenditures are not able to generate another externality which could reduce $\nu$. Moreover, as there is no public health spending in economy, government cannot offset the depreciation of $N_t^h$.

The specification of externality's technology, namely $\vartheta_t \times \left(m_{h,t}^t \times N_t^h\right)^\theta \times \left(N_t^h\right)^{1-\theta}$, describes the fact that only aggregate health spending coming from young healthy households generate the positive externality. The aggregate health expenditures of young households of type $h$ is given by $m_{h,t}^t \times N_t^h$. We assume that the externality resulting from this aggregate amount on health spending depends positively on the size of young healthy households, namely $N_t^h$. We then weight $m_{h,t}^t \times N_t^h$ by $N_t^h$ to illustrate the idea that higher $N_t^h$ generates higher externality level. In other words, $N_t^h$ is a scale variable driving the size of the positive externality resulting from the aggregate health spending of young healthy households. The rate of returns of this scale variable on the positive externality is given by $1-\theta$.

Let $\bar{h}_t$ and $\underline{h}_t$ the relative share of respectively young healthy and unhealthy households in young generation such that:

$$\bar{h}_t = \frac{N_t^h}{N_t} \text{ and } \underline{h}_t = \frac{N_t^l}{N_t}$$

It follows that:

$$\bar{h}_t + \underline{h}_t = 1 \tag{1.5}$$

In the same spirit with Muysken, Yetkiner, and Ziesemer (2003), as $\bar{h}_t$ indicates the share of young healthy households in young generation, we assimilate $\bar{h}_t$ to a health index informing on the overall health in economy at period $t$[2].

Thereafter, for a sake of simplicity, we assume that the non-constant variable indicating the efficiency of aggregate health spending from young healthy households, namely $\vartheta_t$, is specified as follow:

$$\vartheta_t = \frac{N_t}{N_t^h} > 1 \tag{1.6}$$

Thus, by inserting equations (1.1) and (1.5) in equation (1.4), and by retaining the preceding specification, we obtain the following dynamic law:

$$\bar{h}_{t+1} = \frac{1}{(1+n)} \left(m_{h,t}^t\right)^\theta + \frac{(1-\nu)}{(1+n)} \bar{h}_t \tag{1.7}$$

The evolution of $\bar{h}$ is then driven by (i) its previous level and (ii) the private health spending from young healthy households per capita of young generation at the previous period. It implies that the overall health in economy depends only on health spending from young households of type $h$ although all households, whatever their type, make expenditures on health. Note that in equation (1.7), $\nu$ can be assimilated as an exogenous rate at which health index depreciates over time.

As indicated in equation 1.6, the specification of $\vartheta_t$ allows to simplify equation (1.4) but enables mostly to consider the effect of young population size on the externality's technology. Indeed, due to equation 1.6, the level of externality resulting from health spending is rescaled by the size of young generation. Two demographic variables determine then the evolution of the positive externality generated by health spending: the size of young healthy cohort and the size of young households whatever its type.

[2]Note that, according to equation (1.2), $\bar{h}_t$ doesn't affect the health status of all households whatever its type. Households don't then internalize the externality generated by expenditures on health of households of type $h$. It implies that households make health spending to improve their health status but not to enhance the overall health in economy. Moreover, any increase of $\bar{h}_t$ doesn't improve the individual state of health and doesn't affect the type of each household.

### 1.1.2 Household's decisions

Each household of type $i \in \{l; h\}$ is characterized by an additive and separable intertemporal utility function $U_i$ such that:

$$U_i = \phi \log\left(c_{i,t}^t\right) + (1-\phi)\log\left(x_{i,t}^t\right) + \beta\left[\phi \log\left(c_{i,t+1}^t\right) + (1-\phi)\log\left(x_{i,t+1}^t\right)\right] \tag{1.8}$$

Thus, like in Hall and Jones (2007), the instantaneous felicity of household of type $i \in \{l; h\}$ depends on its consumption $c$ and its state of health $x$ at each period. The weight of consumption in $U_i$ is given by $\phi$. $\beta$ indicates the rate at which the instantaneous felicity is discounted at the second period.

As mentioned in Section 1.1.1 and following Hall and Jones (2007), health status of each household reflects also its quality of life. The aim of each household by making health expenditure is then to enhance its quality of life by improving its state of health. And as discussed in the previous Section, by making health spending to improve its health status and then its quality of life, young household of type $h$ generates a positive externality influencing the overall health in economy. However, as households do not internalize this externality, $\bar{h}$ does not affect the well-being of each household.

Each young household, whatever its type, supplies an inelastic labor. The remuneration of this inelastic labor is given by the wage rate $w_t$. Labor income $w_t$ allows young household to consume $c_{i,t}^t$, to spend $m_{i,t}^t$ on health and to save $s_{i,t}^t$. The interest rate of its saving, at the second period, is indicated by $r_{t+1}$. As household of type $i \in \{l; h\}$ is retired at the second period, its income is given by $(1 + r_{t+1})\, s_{i,t}^t$. $(1 + r_{t+1})\, s_{i,t}^t$ allows him to consume $c_{i,t+1}^t$ and spend $m_{i,t+1}^t$ on health at this period. Note that, as there are no pension nor health insurance in economy, household $i$ does not pay any taxes and does not perceive any transfer during its life cycle. The intertemporal budget constraint of household $i \in \{l; h\}$ can then be written as:

$$w_t = c_{i,t}^t + m_{i,t}^t + \frac{c_{i,t+1}^t}{(1 + r_{t+1})} + \frac{m_{i,t+1}^t}{(1 + r_{t+1})}$$

To summarize, the household's problem is:

$$\begin{cases} \underset{c_{i,t}^t, m_{i,t}^t, c_{i,t+1}^t, m_{i,t+1}^t}{Max} & U_i = \phi \log\left(c_{i,t}^t\right) + \gamma_i (1-\phi) \log\left(m_{i,t}^t\right) \\ & + \beta\left[\phi \log\left(c_{i,t+1}^t\right) + \gamma_i (1-\phi) \log\left(m_{i,t+1}^t\right)\right] \\ s.t & w_t = c_{i,t}^t + m_{i,t}^t + \frac{c_{i,t+1}^t}{(1+r_{t+1})} + \frac{m_{i,t+1}^t}{(1+r_{t+1})} \end{cases}$$

First order conditions (referred to below as FOC) of household's problem provide the following results:

$$c_{i,t}^t = \frac{\phi}{(1+\beta)(\gamma_i (1-\phi) + \phi)} w_t \tag{1.9}$$

$$m_{i,t}^t = \frac{\gamma_i (1-\phi)}{(1+\beta)(\gamma_i (1-\phi) + \phi)} w_t \tag{1.10}$$

$$s_{i,t}^t = \frac{\beta}{(1+\beta)} w_t \tag{1.11}$$

$$c_{i,t+1}^t = \frac{\phi}{(\phi + \gamma_i (1-\phi))} (1 + r_{t+1}) s_{i,t}^t \tag{1.12}$$

$$m_{i,t+1}^t = \frac{\gamma_i (1-\phi)}{(\phi + \gamma_i (1-\phi))} (1 + r_{t+1}) s_{i,t}^t \tag{1.13}$$

The next proposition follows.

**Proposition 2** *As long as* $0 < \gamma_h < \gamma_l < 1$*:*

- $c_{h,t}^t > c_{l,t}^t$ *and* $c_{h,t+1}^t > c_{l,t+1}^t$
- $m_{l,t}^t > m_{h,t}^t$ *and* $m_{l,t+1}^t > m_{h,t+1}^t$
- $s_{l,t}^t = s_{h,t}^t = s_t^t$

**Proof 3** *Expressions of optimal consumption and health spending of households of type* $l$ *and* $h$ *differ in parameter* $\gamma$*. It involves that, as* $\gamma_l > \gamma_h$*,* $c_{h,t}^t > c_{l,t}^t$*,* $c_{h,t+1}^t > c_{l,t+1}^t$*,* $m_{l,t}^t > m_{h,t}^t$ *and* $m_{l,t+1}^t > m_{h,t+1}^t$*. Moreover, as expression of* $s_{i,t}^t$ *does not depend on* $\gamma$ *(see equation 1.11), the optimal saving is the same for all households.*

Proposition 2 confirms the result in Proposition 1. Indeed, according to Proposition 2 whatever the generation, health spending of households of type $h$ are always lower than those of type $l$. Indeed, as $0 < \gamma_h < \gamma_l < 1$, healthy households can spend less on health than unhealthy ones without decreasing their well-being. At the opposite, high value of $\gamma$ encourages households of type $l$ to spend much more on health to compensate the low marginal increase in health improvement. Households of type $l$ allocate then more resources to health spending and less amount to consumption unlike to healthy households. That is why $c^t_{h,t} > c^t_{l,t}$, $c^t_{h,t+1} > c^t_{l,t+1}$, $m^t_{l,t} > m^t_{h,t}$ and $m^t_{l,t+1} > m^t_{h,t+1}$. However, the heterogeneity in $\gamma$ does not affect the optimal choice on saving. Although $\gamma_l > \gamma_h$, households of type $l$ and $h$ allocate the same amount to saving during the first period.

### 1.1.3 Firm's decisions

The supply side of economy is characterized by a representative firm producing a single output $Y_t$ at each period. This single output is the numeraire in economy. The price $p_t$ of $Y_t$ is then equal to unit. For analytical convenience, firm's technology to produce $Y_t$ is represented by a constant returns to scale Cobb-Douglas production function such that $Y_t = (K_t)^{\alpha} \left(\bar{h}_t L_t\right)^{1-\alpha}$. In this production function, $L_t$ and $K_t$ indicate the demands for respectively manpower and physical capital. The elasticity of substitution between those inputs is given by $\alpha \in \,]0, 1[$.

We assume in this production function that manpower is weighted by the health index to provide an efficient labor. However, as the health index reflects the positive externality resulting from health spending, the firm does not consider the health index in its program. In other words, health index is an externality for firm and the producer is not able to determine the optimal demand for health index. The firm only determines the optimal demand for manpower. Moreover, the only variable weighted by health index is manpower because it seems not very realistic to assume that health index has any effect on physical capital stock during the production process. Maybe the overall health could affect the efficiency of combination in manpower and physical capital stock like technical progress but we do not retain this configuration. We prefer here to focus on the gross effect of the overall health on manpower as we try to investigate how health can impact labor productivity.

Furthermore, according to firm's technology, the overall health determines in the same way the labor efficiency of both healthy and unhealthy households. Indeed, all young households whatever their types supply an inelastic labor. The manpower is then composed of manpower from unhealthy and healthy young households. Thus, the labor efficiency of every workers depends on the overall health. Basically, the overall health reflects the positive externality resulting from health spending and by definition the externality affects everybody. It follows that young households whatever their types are not able to choose if their labor efficiency depends or not on the overall health. That is why the manpower from healthy and unhealthy households is weighted by the health index.

As usual, the evolution of physical capital stock is given by:

$$K_{t+1} = (1 - \delta_K) K_t + I_t \tag{1.14}$$

with $\delta_K$ the rate at which physical capital depreciates during the production process. As usual for simplicity, but without loss of generality, we assume afterwards that $\delta_K = 1$. It implies that $K_{t+1} = I_t$ with $I_t$ the aggregate amount allocated to renew the depreciated physical capital.

The producer's objective is to choose the amount of capital and labor maximizing its profit $\Pi_t$ taking as given the capital price $u_t = r_t + \delta_K$ and the wage rate $w_t$. The firm's problem is then:

$$Max \;\; \Pi_t = (K_t)^{\alpha} \left(\bar{h}_t L_t\right)^{1-\alpha} - w_t L_t - u_t K_t$$

The FOC of this problem allow to obtain the optimal wage rate:

$$w_t = (1 - \alpha) (k_t)^{\alpha} \left(\bar{h}_t\right)^{1-\alpha} \tag{1.15}$$

and the optimal remuneration of physical capital

$$u_t = \alpha k_t^{\alpha-1} \left(\bar{h}_t\right)^{1-\alpha} \tag{1.16}$$

with $k_t = K_t/L_t$.

Thus, according to equations (1.15) and (1.16), the firm remunerates each factor at its marginal productivity to maximize its profit. It implies that expression of labor productivity is given by equation (1.15). By combining this expression with equation (1.7), we obtain the exact expression of labor productivity, namely

$$w_t = (1-\alpha)(k_t)^{\alpha} \left( \frac{1}{(1+n)} \left(m_{h,t-1}^{t-1}\right)^{\theta} + \frac{(1-\nu)}{(1+n)} \bar{h}_{t-1} \right)^{1-\alpha} \tag{1.17}$$

with

$$\frac{\partial w_t \bar{h}_t}{\partial m_{h,t-1}^{t-1}} = \frac{\theta (1-\alpha)^2}{(1+n)} \left(m_{h,t-1}^{t-1}\right)^{\theta-1} (k_t)^{\alpha} \left(\bar{h}_t\right)^{-\alpha} > 0$$

The next Proposition follows.

**Proposition 3** *Health spending - devoted to improve quality of life - from young healthy households can generate a positive externality able to improve the labor productivity of young generation at next period.*

**Proof 4** *see equation (1.17).*

Thus, we demonstrate through equation (1.17) that health spending devoted to improve the quality of life of one generation can also improve the labor productivity of following generation. This result exhibits an intergenerational transmission of benefit effect from health spending intended to ameliorate the quality of life on labor productivity.

## 1.2 The intergenerational transmission of health

To explain the mechanism behind Proposition 3, we refer to economic and medical literatures on intergenerational transmission of health. Intergenerational transmission of health (referred to below as ITH) is a well-known process highlighted first by epidemiologic academic research (see Ben-shlomo and Kuh (2002) for an extensive literature review). This process describes the fact that health status of previous generations drives the state of health of contemporary and future generations.

### 1.2.1 Related literature on ITH

Economic studies using econometric methods confirm the validity of ITH hypothesis. By using the birth weight as health indicator and by exploiting data set based on California birth certificates, Currie and Moretti (2007) estimate a positive and significant correlation between the state of health of different generations. By regressing child's birth weight on mother's birth weight, they find that mother's low birth weight is accompanied significantly by child's low birth weight.

Sacerdote (2007) obtains similar empirical evidences to those of Currie and Moretti (2007). Sacerdote (2007) exploits data on Korean-American adoptees who were quasi-randomly assigned to adoptive families. He approximates health status through height, weight, Body Mass Index (referred to below as BMI), smoking and drinking status. He estimates that BMI and height exhibit strong transmission from mothers to children for nonadoptees. However, he exhibits no transmission for adoptees. This result suggest that shifts in family environment don't have a large influence on BMI or on probability of being overweight. Nevertheless, Sacerdote (2007) finds that drinking and smoking appear to be very nurture-based. He estimates that parental drinking is strongly associated with adoptee drinking. This result means that adoptees pick up behaviors that they see modeled at home.

Akbulut and Kugler (2008) find more or less similar results by distinguishing natives and immigrants in US population. To undertake their estimation these authors use the

National Longitudinal Survey of Youth 1979 (NLSY79). They approximate the state of health through weight, height, BMI, depression and asthma for both natives and immigrants. They estimate that a significant part of health capital of both natives and immigrants children is explained by health capital of their mother whatever the health index.

Empirical studies conducted on German population exhibit also similar empirical evidences. By exploiting data from German Socio-Economic Panel (GSOEP), Schmidt, Tauchmann, and Gohlmann (2010) analyze the role played by parental smoking on children's smoking initiation. By estimating a discrete time hazard model, they find that parental smoking increases significantly the offspring's hazard to start smoking. Their results suggest that daughters as well as sons of currently smoking mothers are affected by maternal smoking, whereas the marginal effect for girls is twice as high as for boys. Moreover, it seems that not only current parental smoking matters but even children of ex-smokers are more likely to start smoking than kids of never-smoking parents.

Coneus and Spiess (2012) exploit the same database but approximate health through various anthropometric measures (weight and length), information on health disorders (motor impairments, asthma, bronchitis, etc), and self-rated health measures (mother- and father-rated measures of child health, mother and father self-rated health, etc). These authors estimate a strong correlation between mother's height and child's length and weight. They find also that parental health tends often to be transmitted to children via mother. Transmission from father seems to occur significantly only on older children according to Coneus and Spiess (2012).

### 1.2.2 The link between literature on ITH and our model

The main difference between these empirical studies and our theoretical model is that we do not consider explicitly health status as a stock variable. Contrariwise to empirical analysis cited above, our theoretical model assumes that state of health at previous period does not affect health status at current one (see equation 1.2).

We neglect the traditional feature of ITH in order to study ITH through the externality channel. Indeed, as mentioned above, externality is one way through which ITH occurs. Each family way of life or the quality of life induces in general this externality. Sacerdote (2007) underlines the role played by family environment to explain ITH. Sacerdote (2007), Schmidt, Tauchmann, and Gohlmann (2010) and Coneus and Spiess (2012) mention the risk behavior in family to exhibit an ITH. That is why, following this part of literature on ITH, we characterize ITH as an externality evolving over time.

As described in Section 1.1, the evolution of ITH follows the dynamic law of health index. We adopt this specification because the dynamic law of health index replicates closely the ITH process. Indeed, health index is assimilated to a stock variable. Health index at the current period determines health index at the next one (see equation 1.7). In addition, according to equation (1.7), health spending of current young generation drive the health index level of next one. As young households make health expenditures in order to improve their quality of life (see Section 1.1.2), health spending of young households then reflect their preferences for a quality of life. It implies that equation (1.7) characterizes an intergenerational transmission of quality of life. That is why equation (1.7) describes an ITH process occuring through the externality channel.

Thus, we demonstrate through this theoretical model that health spending intended to improve the quality of life can generate a positive externality allowing an ITH. This positive externality affects positively the efficiency of labor supply and can increase the productivity of active people. As health spending devoted to upgrade the quality of life drive the level of this positive externality, we deduce that health spending - intended to improve quality of life - are able to improve the labor productivity through ITH channel. This mechanism traduces the insight behind Proposition 3.

### 1.2.3 The differences between our model and other theoretical analysis on ITH process

Theoretical economic models devoted to analyze the ITH process are scarce. To the best of our knowledge, the first attempt to introduce ITH in a theoretical model was undertaken by Ponthiere (2010). Ponthiere (2010) develops a three-period OLG model in which health status at retired period depends negatively on time allocated to work during mature age. He assumes that time allocated to work determines the lifestyle of each household such that lifestyle is healthy if household spends few time on work and unhealthy if household allocates a lot of time to work. Life style is thereafter transmitted across generation through a socialization process within each family and allows consequently the transmission of health across generations. Ponthiere (2010) uses this framework to demonstrate that in long-run, due to ITH, each economy can reach a steady state where healthy lifestyle dominates unhealthy one[3].

The model proposed by Ponthiere (2010) differs from ours in three points. First, Ponthiere (2010) assumes that ITH occurs through a socialization process while in this Chapter ITH occurs through a positive externality. Second, Ponthiere (2010) assumes that ITH is a function of lifestyle depending on time allocated to work during the mature age. As in Ponthiere (2010), in this Chapter, ITH also depends on lifestyle but this latter is determined by health expenditures of each household. Third, Ponthiere (2010) does not analyze the health effect on labor productivity while this Chapter is devoted to this issue.

To the best of our knowledge, this chapter provides the first attempt to develop an OLG model in which health spending allowing an ITH affects positively labor productivity. Two other papers propose OLG models in which labor productivity depends on health expenditures. The first one is written by Fanti and Gori (2011). These authors develop a two-period OLG model in which government makes health spending in order to improve labor efficiency of old workers. They demonstrate that public health spend-

[3]Ponthiere (2011) proposes an extension of his initial model by introducing parent altruism. Thus, he shows that high altruism induces a high prevalence of healthy lifestyle in long run.

ing affects positively both labor productivity and physical capital stock. The second paper is written by Gori and Sodini (2011). Like Fanti and Gori (2011), these authors develop a two-period OLG model highlighting that government can invest in health in order to improve individual health status which affects labor efficiency of young and mature workers. However, our model and those of Fanti and Gori (2011) and Gori and Sodini (2011) differ in two points. First, unlike to these authors, we neglect public health spending and focus our analysis on private health spending. Second, contrariwise to us, these authors do not analyze the possible externality generated by health spending.

However, both Fanti and Gori (2011) and Gori and Sodini (2011) warn on the ability of public health spending to generate endogenous fluctuation. Indeed, Fanti and Gori (2011) demonstrate that public health spending can induce some complex cycles in economy. Gori and Sodini (2011) find that public investments in health can generate multiplicity of equilibria and may be a source of local indeterminacy and complex dynamics. To check if private health spending improving the quality of life are able to create similar endogenous fluctuation in our OLG model, we determine first in Section 1.3 the intertemporal equilibrium of our OLG model. Thereafter, we study in Section 1.4 the local stability of dynamical system characterizing the intertemporal equilibrium of our model.

## 1.3 Model's equilibrium

As described in previous Sections, the representative firm and households of type $i \in \{l; h\}$ compose agents who form the economy. Following the class of general equilibrium model, market process allows the coordination between these agents. This market process occurs on labor, capital and goods market such that all of them operate without any friction. It implies that labor market clears, namely $L_t = N_t$.

$Y_t = C_t + M_t + I_t$ provides the goods market clearing condition with $C_t$ and $M_t$ the aggregate amount of respectively consumption and health expenditures at period

$t$ such that:

$$C_t = N_t^h c_{h,t}^t + N_t^l c_{l,t}^t + N_{t-1}^h c_{h,t}^{t-1} + N_{t-1}^l c_{l,t}^{t-1} \tag{1.18}$$

and:

$$M_t = N_t^h m_{h,t}^t + N_t^l m_{l,t}^t + N_{t-1}^h m_{h,t}^{t-1} + N_{t-1}^l m_{l,t}^{t-1} \tag{1.19}$$

Moreover, as (i) returns to scale of production function is constant and as (ii) each factor is remunerated at its marginal productivity, Euler's theorem is verified and involves that $Y_t = w_t L_t + u_t K_t$. By inserting the expression of $Y_t$, equations (1.18) and (1.19) in goods market clearing condition, by exploiting equation (1.14) and by taking into account the budget constraint of each household of type $i \in \{l; h\}$, goods market clearing condition becomes:

$$\begin{aligned} w_t L_t + u_t K_t = {} & N_t^h \left(w_t - m_{h,t}^t - s_{h,t}^t\right) + N_t^l \left(w_t - m_{l,t}^t - s_{l,t}^t\right) \\ & + N_{t-1}^h \left(\left(1 + r_t\right) s_{h,t-1}^{t-1} - m_{h,t}^{t-1}\right) + N_{t-1}^l \left(\left(1 + r_t\right) s_{l,t-1}^{t-1} - m_{l,t}^{t-1}\right) \\ & + N_t^h m_{h,t}^t + N_t^l m_{l,t}^t + N_{t-1}^h m_{h,t}^{t-1} + N_{t-1}^l m_{l,t}^{t-1} + K_{t+1} - \left(1 - \delta_K\right) K_t \end{aligned}$$

After simplification:

$$w_t L_t + u_t K_t = L_t w_t + K_{t+1} - \left(1 - \delta_K\right) K_t - N_t^h s_{h,t}^t - N_t^l s_{l,t}^t + N_{t-1}^h \left(1 + r_t\right) s_{h,t-1}^{t-1} + N_{t-1}^l \left(1 + r_t\right) s_{l,t-1}^{t-1}$$

As in Proposition 2, $s_{h,t}^t = s_{l,t}^t = s_t^t$, the previous equality can be written as follow:

$$\left(1 + r_t\right) K_t + N_t s_t^t = K_{t+1} + N_{t-1} \left(1 + r_t\right) s_{t-1}^{t-1}$$

As usual, at initial period, there is an initial physical capital stock $K_0$ which is equal to the aggregate saving $N_{-1} \times s_{-1}$[4]. It follows that, recursively, $K_0 = N_{-1} \times s_{-1}$ implies $K_t = N_{t-1} s_{t-1}^{t-1}$. This equality involves that equilibrium on labor and goods markets induces the equilibrium on physical capital market. Walras' law is verified

[4] $N_{-1} \times s_{-1}$ is the only income perceived by retired households of type $i \in \{l; h\}$ during this initial period and allows them to consume and make expenditures on health.

and $K_{t+1} = N_t s_t^t$ can be written as:

$$k_{t+1} = \frac{1}{(1+n)} s_t^t \tag{1.20}$$

By substituting $s_t^t$ by equation (1.11) in (1.20) and by replacing $w_t$ in equation (1.11) by (1.15), equation (1.20) becomes:

$$k_{t+1} = \frac{\beta(1-\alpha)}{(1+n)(1+\beta)} (k_t)^{\alpha} \left(\bar{h}_t\right)^{1-\alpha} \tag{1.21}$$

The equilibrium on the three markets is then characterized by equation (1.21) describing also the evolution of physical capital stock over time. It follows that evolution of $k_{t+1}$ depends on its previous level and on previous level of health index also. An intertemporal general equilibrium of this model is thus characterized by evolutions of both physical capital and health index over time.

The evolution of health index over time is informed by equation (1.7). By substituting $m_{h,t}^t$ by equation (1.10) in equation (1.7), the evolution of health index follows:

$$\bar{h}_{t+1} = \frac{1}{(1+n)} \left( \frac{\gamma_h (1-\phi)}{(1+\beta)(\gamma_h(1-\phi)+\phi)} w_t \right)^{\theta} + \frac{(1-\nu)}{(1+n)} \bar{h}_t$$

By introducing $w_t = (1-\alpha)(k_t)^{\alpha} \left(\bar{h}_t\right)^{-\alpha}$ in this equation, the evolution of $\bar{h}_{t+1}$ is thus given by:

$$\bar{h}_{t+1} = \frac{1}{(1+n)} \left( \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)} \right)^{\theta} (k_t)^{\theta\alpha} \left(\bar{h}_t\right)^{(1-\alpha)\theta} + \frac{(1-\nu)}{(1+n)} \bar{h}_t \tag{1.22}$$

The next proposition follows.

**Proposition 4** *An intertemporal general equilibrium for this economy is a non-negative sequence $\left\{k_t; \bar{h}_t\right\}_{t=0}^{+\infty}$ such that the following system is verified:*

$$k_{t+1} = \frac{\beta(1-\alpha)}{(1+n)(1+\beta)} (k_t)^{\alpha} \left(\bar{h}_t\right)^{1-\alpha} \tag{1.23}$$

$$\bar{h}_{t+1} = \frac{1}{(1+n)} \left( \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h (1-\phi)+\phi)} \right)^{\theta} (k_t)^{\theta\alpha} \left(\bar{h}_t\right)^{(1-\alpha)\theta} + \frac{(1-\nu)}{(1+n)} \bar{h}_t \tag{1.24}$$

*with $k_0$ and $h_0$ the two pre-determined variables of this system.*

Thus, the positive externality - generated by health spending devoted to improve quality of life - implies an intertemporal general equilibrium characterized by a two dimensional system describing the dynamic law of respectively physical capital stock and health index.

## 1.4 The dynamical system

### 1.4.1 The steady-state

The system (1.23)-(1.24) reaches a steady-state if and only if $k_{t+1} = k_t = k$ and $\bar{h}_{t+1} = \bar{h}_t = \bar{h}$. It involves that, at the steady-state, the system (1.23 )-(1.24) becomes:

$$k = \frac{\beta (1-\alpha)}{(1+n)(1+\beta)} k^{\alpha} \bar{h}^{1-\alpha}$$

$$\bar{h} = \frac{1}{(1+n)} \left( \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h (1-\phi)+\phi)} \right)^{\theta} k^{\theta\alpha} \bar{h}^{(1-\alpha)\theta} + \frac{(1-\nu)}{(1+n)} \bar{h}$$

The next proposition follows.

**Proposition 5** *The system (1.23)-(1.24) possesses (i) one trivial steady-state described by the couple $\left\{k^{tri}, \bar{h}^{tri}\right\}$ such that $k^{tri} = 0$ and $\bar{h}^{tri} = 0$ and (ii) an unique non-trivial steady-state characterized by the couple $\left\{k, \bar{h}\right\}$ such that:*

$$k = \left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} \left( \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h (1-\phi)+\phi)} \right)^{\frac{\theta}{1-\theta}} \left( \frac{(1-\alpha)\beta}{(1+n)(1+\beta)} \right)^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)} \tag{1.25}$$

$$\bar{h} = \left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} \left( \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h (1-\phi)+\phi)} \right)^{\frac{\theta}{1-\theta}} \left( \frac{(1-\alpha)\beta}{(1+n)(1+\beta)} \right)^{\frac{(1-\alpha)\theta\alpha}{1-\theta}} \tag{1.26}$$

*if initial values of physical capital and health index are equal respectively to $k_0$ and $h_0$.*

For convenience, let

$$B = \frac{(1-\alpha)\,\beta}{(1+n)\,(1+\beta)}$$

and

$$C = \frac{\gamma_h\,(1-\phi)\,(1-\alpha)}{(1+\beta)\,(\gamma_h\,(1-\phi)+\phi)}$$

It follows that expressions of physical capital stock and health index at the non-trivial steady-state can be written respectively as:

$$k = \left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

$$\bar{h} = \left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

The next Proposition follows.

**Proposition 6** *The non-trivial steady-state is plausible if and only if* $\nu > \bar{\nu}$ *with* $\bar{\nu} = (1+n)\,C^{\theta}B^{(1-\alpha)\theta\alpha} - n$.

**Proof 5** *As* $\bar{h}$ *is an index, its level should not ever exceed the unit. This condition implies that* $\bar{h} < 1$. *This condition is verified if and only if* $\nu > \bar{\nu}$ *with* $\bar{\nu} = (1+n)\,C^{\theta}B^{(1-\alpha)\theta\alpha} - n$.

Indeed, $\bar{h}$ indicates the health index level at the non-trivial steady-state. As the health index is an index, by definition, its value ranges necessarily form 0 to 1 even if the economy reaches the non-trivial steady-state. Beyond this range, the health index level is not plausible. That is why the condition indicated in Proposition 6 must be verified at the steady-state.

### 1.4.2 Comparative static

Expressions of both physical capital stock and health index at the steady-state are primarily composed by exogenous parameters. In other words, levels of $k$ and $\bar{h}$ depend on exogenous parameters' level. Could it be then possible to upgrade the levels of $k$ and $\bar{h}$ by changing the level of exogenous parameters determining their expression ? To answer this question, we undertake a comparative static analysis on $k$ and $\bar{h}$ by varying the level of $\gamma_h$, $\beta$, $\bar{h}$, $\phi$ and $\nu$.

One crucial parameter determining the levels of $k$ and $\bar{h}$ is $\gamma_h$. Initially, $\gamma_h$ indicates the rate of returns of health spending from healthy households on their quality of life. But, due to the positive externality, $\gamma_h$ gives also the rate of returns of healthy households expenditures on health on the overall health in economy. It implies that any variation in $\gamma_h$ reflects (i) a variation in rate of returns of health spending from households of type $h$ and (ii) a variation in effect of these expenditures on the overall health in economy. The effects of a variation in $\gamma_h$ on levels of physical capital stock and health index at the steady-state are given by:

$$\frac{\partial k}{\partial \gamma_h} = \left( \frac{\theta}{(1-\theta)(\gamma_h)} - \frac{\theta(1-\phi)}{(1-\theta)(\gamma_h(1-\phi)+\phi)} \right) \left( \frac{1+n}{n+\nu} \right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

and

$$\frac{\partial \bar{h}}{\partial \gamma_h} = \left( \frac{\theta}{(1-\theta)(\gamma_h)} - \frac{\theta(1-\phi)}{(1-\theta)(\gamma_h(1-\phi)+\phi)} \right) \left( \frac{1+n}{n+\nu} \right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

The next proposition follows.

**Proposition 7** *At the steady-state, any increase in $\gamma_h$ induces a rise in $k$ and $\bar{h}$ if and only if the weight of consumption in intertemporal utility function of household of type $i \in \{l; h\}$ is positive. This condition is always verified.*

**Proof 6**

$$\frac{\partial k}{\partial \gamma_h} > 0 \text{ and } \frac{\partial \bar{h}}{\partial \gamma_h} > 0$$

*if*

$$\frac{\theta}{(1-\theta)(\gamma_h)} - \frac{\theta(1-\phi)}{(1-\theta)(\gamma_h(1-\phi)+\phi)} > 0$$

*This condition is verified if and only if $\phi > 0$.*

To understand the insight behind Proposition 7, note that any increase in $\gamma_h$ incites healthy households to expend more on health. Indeed, a rise in $\gamma_h$ diminishes the marginal increase in health improvement of household of type $h$. To compensate this decrease, healthy households have an incentive to increase their health spending in order to keep unchanged their quality of life. It implies that higher $\gamma_h$ incites healthy households to allocate much more amount to health spending. Higher amount to health expenditures upgrades health index, labor productivity, labor income, saving and at least the physical capital. That is why $\partial k/\partial\gamma_h > 0$ and $\partial\bar{h}/\partial\gamma_h > 0$.

Following this insight, very high level of $\gamma_h$ could incite healthy households to allocate all of their revenue to health spending. Unfortunately, healthy households could devote all of their income in health if and only if health is the only component able to improve their well-being. However, this configuration occurs if and only if $\phi \leq 0$. Indeed, $\phi$ indicates the weight of consumption in utility function (see equation 1.8). Thus, $\phi \leq 0$ means that consumption decreases the individual well-being whatever the period in life-cycle. At the opposite, $\phi > 0$ implies that household is able to increase its well-being by consuming. In other words, $\phi > 0$ ensures that healthy households are not incited to devote all of their revenues to health expenditures after a rise in $\gamma_h$. $\phi > 0$ ensures a trade-off between consumption and health spending and is a condition to motivate healthy households to make saving in order to consume and expend on health at the second period. At the opposite, $\phi \leq 0$ involves that healthy households make saving only to spend on health at the second period. Thus, $\phi \leq 0$ could diminish the level of healthy households saving. The drop in their saving decreases the physical capital stock, labor productivity, labor income, health spending and health index. It explains why if $\phi \leq 0$ then $\partial k/\partial\gamma_h < 0$ and $\partial\bar{h}/\partial\gamma_h < 0$ .

Any variation in $\phi$ affects also the levels of $k$ and $\bar{h}$. The effects of any variation in $\phi$ on levels of physical capital and health index at the steady-state are given by

$$\frac{\partial k}{\partial \phi} = -\left(\frac{\theta}{(1-\theta)(1-\phi)} + \frac{\theta(1-\gamma_h)}{(1-\theta)(\phi+\gamma_h(1-\phi))}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

$$\frac{\partial \bar{h}}{\partial \phi} = -\left(\frac{\theta}{(1-\phi)(1-\theta)} + \frac{\theta(1-\gamma_h)}{(1-\theta)(\gamma_h(1-\phi)+\phi)}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

The next proposition follows.

**Proposition 8** *At the steady-state, any increase in $\phi$ induces a decrease in $k$ and $\bar{h}$.*

**Proof 7** *It is obvious to see that*

$$\frac{\partial k}{\partial \phi} < 0 \text{ and } \frac{\partial \bar{h}}{\partial \phi} < 0$$

Proposition 8 indicates that any increase in $\phi$ affects negatively $k$ and $\bar{h}$. Indeed, high weight of consumption in utility function implies low weight of life quality in $U_i$. Low weight of life quality in $U_i$ discourages households to make health expenditures. The decrease in health spending from healthy households reduces the health index level, labor productivity, labor income, saving and then physical capital stock. This mechanism explains the insight behind Proposition 8.

An other parameter determining the levels of $k$ and $\bar{h}$ is $\beta$. Parameter $\beta$ reflects the rate at which instantaneous felicity is discounted at the second period. It implies that high value of $\beta$ should incite households to increase their saving to consume and make more health spending at the second period. The raise in saving should then expand the physical capital stock. That is why, most of the time, $\beta$ influences positively the level of $k$ in the class of OLG model. Here, the variation effects of $\beta$ on $k$ and $\bar{h}$ are described by:

$$\frac{\partial k}{\partial \beta} = \left(\frac{(1-\alpha)\theta\alpha}{(1-\theta)\beta} + \frac{(1-\alpha)}{\beta} - \frac{1+2\theta\alpha-\alpha-\theta\alpha^2}{(1-\theta)(1+\beta)}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

$$\frac{\partial \bar{h}}{\partial \beta} = \left(\frac{(1-\alpha)\theta\alpha}{(1-\theta)\beta} - \frac{(1+\alpha-\alpha^2)\theta}{(1-\theta)(1+\beta)}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

The next proposition follows.

**Proposition 9** *At the steady-state, higher discount rate always increases the level of $k$ but induces a rise in $\bar{h}$ if and only if $\hat{\beta} > \beta$ such that $\hat{\beta} = \alpha(1-\alpha)$.*

**Proof 8** $\partial k/\partial\beta > 0$ *implies that*

$$\frac{(1-\alpha)\theta\alpha}{(1-\theta)\beta} + \frac{(1-\alpha)}{\beta} - \frac{1+2\theta\alpha-\alpha-\theta\alpha^2}{(1-\theta)(1+\beta)} > 0$$

*and this condition is verified if*

$$\frac{1-\theta-\alpha(1+2\theta+\theta\alpha)}{\theta} > \beta$$

*As $\theta \in ]0;1[$ and $\alpha \in ]0;1[$, this condition is equivalent to $1 > \beta$. However, as we initially assume that $\beta \in ]0;1[$ this condition is always verified.*

$\partial\bar{h}/\partial\beta > 0$ *implies that*

$$\frac{(1-\alpha)\theta\alpha}{(1-\theta)\beta} - \frac{(1+\alpha-\alpha^2)\theta}{(1-\theta)(1+\beta)} > 0$$

*And this condition is satisfied if and only if $\alpha(1-\alpha) > \beta$.*

Proposition 9 underlines that any increase in discount factor expands the levels of both $k$ and $\bar{h}$ at the steady-state if and only if $\hat{\beta} > \beta$. Indeed, in the same line with the class of OLG model, higher discount rate incites households to save more. Higher saving increases physical capital stock, labor productivity, labor income, health expenditure and at least health index. However, the positive impacts from an increase in $\beta$ on $\bar{h}$ vanish if $\beta > \hat{\beta}$. Indeed, higher discount rate incites to increase the saving. The rise in saving decreases resources from young healthy generation allocated to health spending. The decrease in health spending from young healthy households affects negatively the health index level (see Equation 1.7). That is why, if $\hat{\beta} < \beta$, the level of $\bar{h}$ diminishes at the steady-state.

Level of $k$ and $\bar{h}$ vary also with respect to $n$. Indeed,

$$\frac{\partial k}{\partial n}=\left(\frac{1-(1-\alpha)(1-(1-\alpha)\theta)}{(1-\theta)(1+n)}-\frac{1}{(1-\theta)(n+\nu)}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}}C^{\frac{\theta}{1-\theta}}B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

$$\frac{\partial\bar{h}}{\partial n}=\left(\frac{1-(1-\alpha)\theta\alpha}{(1-\theta)(1+n)}-\frac{1}{(1-\theta)(n+\nu)}\right)\left(\frac{1+n}{n+\nu}\right)^{\frac{1}{1-\theta}}C^{\frac{\theta}{1-\theta}}B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

The next proposition follows.

**Proposition 10** *Any increase in population growth rate reduces the levels of both $k$ and $\bar{h}$ at the steady-state.*

**Proof 9** $\partial k/\partial n>0$ *implies that*

$$\frac{1-(1-\alpha)(1-(1-\alpha)\theta)}{(1-\theta)(1+n)}-\frac{1}{(1-\theta)(n+\nu)}>0$$

*This condition is verified if and only if* $(1-\alpha)(n+\nu)(1-(1-\alpha)\theta)<-(1-\nu)$. *But this condition is equivalent to* $(1-\alpha)(n+\nu)(1-(1-\alpha)\theta)<0$. *However, as* $\alpha\in]0;1[$, $n>0$, $\nu\in]0;1[$ *and* $\theta\in]0;1[$, *this condition can never be satisfied. That is why* $\partial k/\partial n<0$.

*In addition,* $\partial\bar{h}/\partial n>0$ *implies that*

$$\frac{1-(1-\alpha)\theta\alpha}{(1-\theta)(1+n)}-\frac{1}{(1-\theta)(n+\nu)}>0$$

*This condition is verified if and only if* $(1-\alpha)(n+\nu)\theta\alpha<-(1-\nu)$. *But this condition is equivalent to* $(1-\alpha)(n+\nu)\theta\alpha<0$. *However, as* $\alpha\in]0;1[$, $n>0$, $\nu\in]0;1[$ *and* $\theta\in]0;1[$, *this condition can never be satisfied. That is why* $\partial\bar{h}/\partial n<0$.

Thus, the rise in population growth rate at the steady-state reduces the physical capital stock per capita. Lower physical capital stock diminishes labor productivity, labor income, resources allocated to health spending and at least health index.

The same negative effects are found when the depreciation rate of health index increases. Indeed,

$$\frac{\partial k}{\partial v} = -\frac{1}{(1-\theta)(n+\nu)}\left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{(1-\theta)}+(1-\alpha)}$$

$$\frac{\partial \bar{h}}{\partial v} = -\frac{1}{(1-\theta)(n+\nu)}\left[\frac{(1+n)}{(n+\nu)}\right]^{\frac{1}{1-\theta}} C^{\frac{\theta}{1-\theta}} B^{\frac{(1-\alpha)\theta\alpha}{1-\theta}}$$

It is obvious to see that $\partial k/\partial v < 0$ and $\partial \bar{h}/\partial v < 0$. This result is due to the fact that any increase in $v$ decreases the health index, labor productivity, labor income, the available resource for saving and at least physical capital stock at the steady-state. That is why $\partial k/\partial v < 0$ and $\partial \bar{h}/\partial v < 0$.

To summarize, according to this comparative static analysis, high level of $\gamma_h$ and $\beta$ could upgrade the levels of $k$ and $\bar{h}$. At the opposite, high level of $\phi$, $n$ and $\nu$ could decrease the levels of both physical capital stock and health index at the steady-state.

### 1.4.3 Local stability

Varying the level of exogenous parameters composing the expressions of $k$ and $\bar{h}$ induces a variation in these variables' levels (see Section 1.4.2). However, any variation of these exogenous parameters can also affect the local stability of the non-trivial steady-state and generate some endogenous fluctuations. We then analyze through this section if (i) the non-trivial steady-state can lose its stability and if (ii) the positive externality resulting from private health spending - intended to improve quality of life - can generate endogenous fluctuation like public health expenditure in Fanti and Gori (2011) and Gori and Sodini (2011).

#### 1.4.3.1 Analytical method

We exploit the analytical method developed by Grandmont, Pintus, and de Vilder (1998) to study the local stability of the non-trivial steady-state. For that purpose, we linearize the system (1.23)-(1.24) around the non-trivial steady-state. The linearized dynamical system provides a Jacobian matrix associated to this latter. The value of each eigenvalue of the Jacobian matrix is thereafter compared with respect to the unit circle. The stability of the dynamical system around the steady-state is deduced by the number of eigenvalues included in the unit circle.

Equations (1.23) and (1.24) characterize the dynamical system. By applying the earlier simplification, this system is equivalent to:

$$k_{t+1} = Bk_t^{\alpha}\bar{h}_t^{(1-\alpha)}$$

$$\bar{h}_{t+1} = \frac{1}{(1+n)}C^{\theta}\left(k_t\right)^{\theta\alpha}\left(\bar{h}_t\right)^{(1-\alpha)\theta} + \frac{(1-\nu)}{(1+n)}\bar{h}_t$$

The total differential of this system is:

$$dk_{t+1} - \alpha Bk_t^{\alpha-1}\bar{h}_t^{(1-\alpha)}dk_t - (1-\alpha)\,Bk_t^{\alpha}\bar{h}_t^{-\alpha}dh_t = 0$$

$$dh_{t+1} - \frac{(1-\nu)}{(1+n)}dh_t - (1-\alpha)\,\theta D\left(k_t\right)^{\theta\alpha}\left(\bar{h}_t\right)^{(1-\alpha)\theta-1}dh_t - \theta\alpha D\left(k_t\right)^{\theta\alpha-1}\left(\bar{h}_t\right)^{(1-\alpha)\theta}dk_t = 0$$

with

$$D = \frac{1}{(1+n)}C^{\theta}$$

Thus, near the non-trivial steady-state, the system (1.23)-(1.24) is equivalent to:

$$\frac{dk_{t+1}}{k} = \alpha\frac{dk_t}{k} + (1-\alpha)\,\frac{dh_t}{h}$$

$$\frac{dh_{t+1}}{h} = \frac{(n+\nu)}{(1+n)}\theta\alpha\frac{dk_t}{k} + \left(\frac{(1-\nu)}{(1+n)} + (1-\alpha)\,\theta\frac{(n+\nu)}{(1+n)}\right)\frac{dh_t}{h}$$

as

$$k = Bk^{\alpha}\bar{h}^{(1-\alpha)} \text{ and } \frac{(n+\nu)}{(1+n)}\bar{h} = D\left(k_t\right)^{\theta\alpha}\bar{h}^{(1-\alpha)\theta}$$

The next proposition follows.

**Proposition 11** *Near the non-trivial steady-state, the linearized expression of system*

*(1.23)-(1.24) is described by the couple* $\left\{\frac{dk_{t+1}}{k};\frac{dh_{t+1}}{h}\right\}$ *such that:*

$$\frac{dk_{t+1}}{k}=\alpha\frac{dk_t}{k}+(1-\alpha)\frac{dh_t}{h} \tag{1.27}$$

$$\frac{dh_{t+1}}{h}=\frac{(n+\nu)}{(1+n)}\theta\alpha\frac{dk_t}{k}+\left(\frac{(1-\nu)}{(1+n)}+(1-\alpha)\,\theta\frac{(n+\nu)}{(1+n)}\right)\frac{dh_t}{h} \tag{1.28}$$

*with* $J$ *its Jacobian matrix such that:*

$$J=\begin{pmatrix}\alpha & 1-\alpha\\ \theta\alpha\frac{(n+\nu)}{(1+n)} & \frac{(1-\nu)}{(1+n)}+(1-\alpha)\,\theta\frac{(n+\nu)}{(1+n)}\end{pmatrix}$$

Let $\zeta_1$ and $\zeta_2$ two eigenvalues of $J$ and the roots of the characteristic polynomial $P(\zeta)$ of $J$ such that:

$$P(\zeta)=\zeta^2-\left(\alpha+\frac{(1-\nu)}{1+n}+\theta\frac{(1-\alpha)\,(n+\nu)}{1+n}\right)\zeta+\alpha\frac{(1-\nu)}{(1+n)}$$

As a matter of fact, $P(\zeta)=\zeta^2-tr(J)\zeta+\det(J)$ with $\det(J)$ and $tr(J)$ respectively the determinant and the trace of $J$ such that

$$\det(J)=\alpha\frac{(1-\nu)}{(1+n)} \tag{1.29}$$

and

$$tr(J)=\alpha+\frac{(1-\nu)}{1+n}+\theta\frac{(1-\alpha)\,(n+\nu)}{1+n} \tag{1.30}$$

According to method proposed by Grandmont, Pintus, and de Vilder (1998), as $\det(J)=\zeta_1\times\zeta_2$ and $tr(J)=\zeta_1+\zeta_2$, the position of $\zeta_1$ and $\zeta_2$ with respect to the unit circle can be characterized inside a Cartesian plane where $\det(J)$ is on the vertical axis and $tr(J)$ is on the horizontal axis (see Figure 1.1). The $(\det(J),tr(J))$-plane can then be divided into a number of regions - distinguished by the nature of eigenvalues in each region - by building three auxiliary lines (see Figure 1.1). The two first auxiliary lines are obtained by evaluating $P(\zeta=1)=0$ and $P(\zeta=-1)=0$. Indeed, when one eigenvalue is equal to 1 then $P(\zeta=1)=0$, namely $\det(J)-tr(J)+1=0$, and a straight line $(AC)$ going through the points $(0,-1)$ and $(1,0)$ in the $(\det(J), tr(J))$-plane is obtained. When one eigenvalue is equal to $-1$ then $P(\zeta=-1)=0$, namely $\det(J)+tr(J)+1=0$, and a straight line $(BA)$ going through the points $(-1,0)$ and $(0,-1)$ is obtained. The last auxiliary line is deduced by calculating $\det(J)=1$. The horizontal straight line $(BC)$ characterizes $\det(J)=1$ in the $(\det(J), tr(J))$-plane. It follows that inside the $ABC$ triangle, two eigenvalues lie inside the unit circle. On the right or on the left of both $(AB)$ and $(AC)$, $J$ possesses one stable and one unstable eigenvalue. Otherwise, $J$ possesses two unstable eigenvalues.

According to equations (1.29) and (1.30), $\det(J)\in(0,1)$ and $tr(J)>0$. Moreover,

$$P(1)=1-\alpha-\frac{(1-\alpha)}{(1+n)}\left(1-\nu+\theta\left(n+\nu\right)\right)$$

and

$$P(-1)=\alpha\frac{(1-\nu)}{(1+n)}+\alpha+\frac{(1-\nu)}{1+n}+\theta\frac{(1-\alpha)\left(n+\nu\right)}{1+n}+1$$

It is obvious to see that $P(-1)>0$. However, $P(1)>0$ if and only if

$$1-\alpha-\frac{(1-\alpha)}{(1+n)}\left(1-\nu+\theta\left(n+\nu\right)\right)>0$$

And this condition is verified if $1>\theta$. As $\theta\in\,]0;1[$, according to our initial assumption, this condition is always satisfied. It implies that $P(1)>0$. Thus, as $\det(J)\in(0,1)$ and as $P(1)>0$ and $P(-1)>0$, $\zeta_1$ and $\zeta_2$ lie necessarily inside the triangle $ABC$. The next proposition follows.

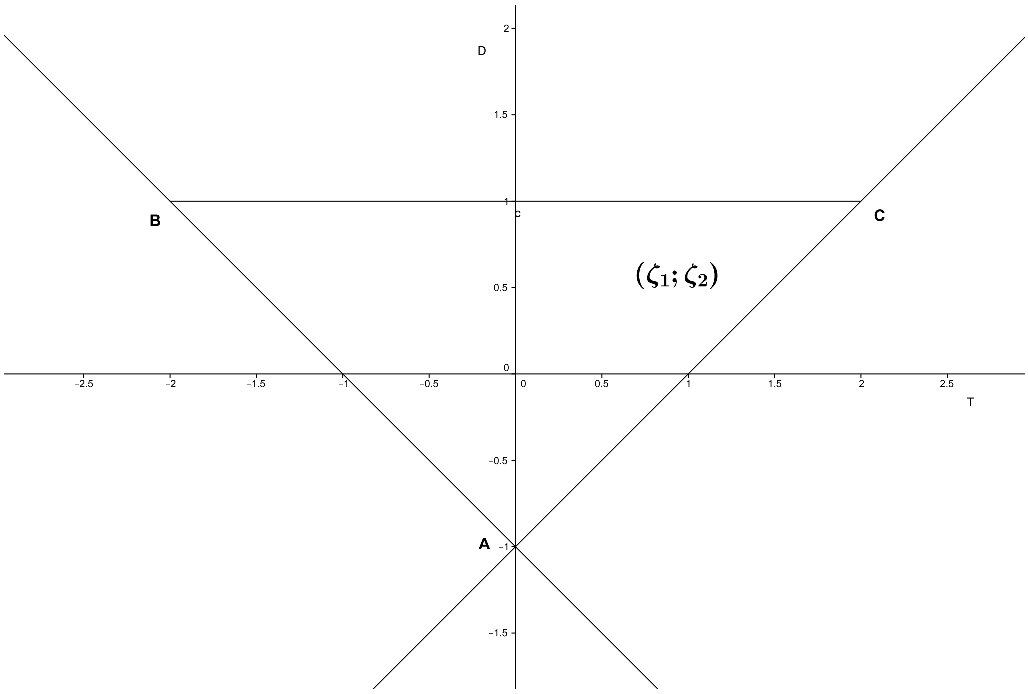
**Proposition 12** *As $\alpha\in(0,1)$, $n\in(0,1)$, $\nu\in(0,1)$ and $\theta\in(0,1)$, $J$ possesses two stable eigenvalues and the non-trivial steady state described by the couple $\left\{k;\bar{h}\right\}$ is a sink.*

**Corollary 2** *As long as $\alpha\in(0,1)$, $n\in(0,1)$, $\nu\in(0,1)$ and $\theta\in(0,1)$ there is no room for local bifurcation.*

Thus, according to Proposition 12, the positive externality resulting from private health spending - devoted to ameliorate quality of life - does not provide a dynamical

Figure 1.1: The (T,D)-plane




system generating endogenous fluctuation. Based on all previous assumptions, we do not find then the same result as Fanti and Gori (2011) and Gori and Sodini (2011) on the ability of public health spending to generate endogenous fluctuation. It implies that the system (1.23)-(1.24) always converges to the steady-state characterized by the couple $\left\{k;\bar{h}\right\}$.

#### 1.4.3.2 Graphical method

Exploiting the graphical method is another way to check the local stability of the non-trivial steady-state. This method allows to illustrate graphically the convergence of the system (1.23 )-(1.24) to the steady-state characterized by the couple $\left\{k;\bar{h}\right\}$.

Let $\kappa\left(k_t,\bar{h}_t\right)=k_{t+1}$ and $\Psi\left(k_t,\bar{h}_t\right)=\bar{h}_{t+1}$ such that:

$$\kappa\left(k_t,\bar{h}_t\right)=\frac{\beta\left(1-\alpha\right)}{\left(1+n\right)\left(1+\beta\right)}\left(k_t\right)^{\alpha}\left(\bar{h}_t\right)^{(1-\alpha)}$$

$$\Psi\left(k_t,\bar{h}_t\right)=\frac{1}{(1+n)}\left(\frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)}\right)^{\theta}(k_t)^{\theta\alpha}\left(\bar{h}_t\right)^{(1-\alpha)\theta}+\frac{(1-\nu)}{(1+n)}\bar{h}_t$$

Assume that $\kappa\left(k_t,\bar{h}_t\right)=k_t$ and $\Psi\left(k_t,\bar{h}_t\right)=\bar{h}_t$. Thus,

$$\kappa\left(k_t,\bar{h}_t\right)=k_t\Leftrightarrow\frac{\beta(1-\alpha)}{(1+n)(1+\beta)}(k_t)^{\alpha}\left(\bar{h}_t\right)^{(1-\alpha)}=k_t$$

and

$$\Psi\left(k_t,\bar{h}_t\right)=\bar{h}_t\Leftrightarrow\frac{1}{(1+n)}\left(\frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)}\right)^{\theta}(k_t)^{\theta\alpha}\left(\bar{h}_t\right)^{(1-\alpha)\theta}+\frac{(1-\nu)}{(1+n)}\bar{h}_t=\bar{h}_t$$

It involves that:

$$\kappa\left(k_t,\bar{h}_t\right)=k_t\Leftrightarrow\bar{h}_t=\left[\frac{(1+n)(1+\beta)}{\beta(1-\alpha)}\right]^{\frac{1}{(1-\alpha)}}k_t$$

and

$$\Psi\left(k_t,\bar{h}_t\right)=\bar{h}_t\Leftrightarrow\left[\frac{1}{(n+\nu)}\right]^{\frac{1}{1-(1-\alpha)\theta}}\left(\frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)}\right)^{\frac{\theta}{1-(1-\alpha)\theta}}(k_t)^{\frac{\theta\alpha}{1-(1-\alpha)\theta}}=\bar{h}_t$$

Through the first equality, namely $\kappa\left(k_t,\bar{h}_t\right)=k_t$, we deduce that:

$$\kappa\left(k_t,\bar{h}_t\right)>k_t\Leftrightarrow\bar{h}_t>\left[\frac{(1+n)(1+\beta)}{\beta(1-\alpha)}\right]^{\frac{1}{(1-\alpha)}}k_t$$

$$\kappa\left(k_t,\bar{h}_t\right)<k_t\Leftrightarrow\bar{h}_t<\left[\frac{(1+n)(1+\beta)}{\beta(1-\alpha)}\right]^{\frac{1}{(1-\alpha)}}k_t$$

Through the second equality, namely $\Psi\left(k_t,\bar{h}_t\right)=\bar{h}_t$, we deduce that:

$$\Psi\left(k_t,\bar{h}_t\right)>\bar{h}_t\Leftrightarrow\bar{h}_t<\left[\frac{1}{(n+\nu)}\right]^{\frac{1}{1-(1-\alpha)\theta}}\left(\frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)}\right)^{\frac{\theta}{1-(1-\alpha)\theta}}(k_t)^{\frac{\theta\alpha}{1-(1-\alpha)\theta}}$$

$$\Psi\left(k_t,\bar{h}_t\right)<\bar{h}_t\Leftrightarrow\bar{h}_t>\left[\frac{1}{(n+\nu)}\right]^{\frac{1}{1-(1-\alpha)\theta}}\left(\frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)}\right)^{\frac{\theta}{1-(1-\alpha)\theta}}(k_t)^{\frac{\theta\alpha}{1-(1-\alpha)\theta}}$$

Moreover, according to $\Psi\left(k_t, \bar{h}_t\right) = \bar{h}_t$, $\bar{h}_t$ is a positive and concave function of $k_t$ as:

$$\frac{\partial \bar{h}_t}{\partial k_t} = \frac{\theta\alpha}{\left(1-(1-\alpha)\theta\right)} \times \left[\frac{1}{(n+\nu)}\right]^{\frac{1}{1-(1-\alpha)\theta}} C^{\frac{\theta}{1-(1-\alpha)\theta}} \left(k_t\right)^{\frac{\theta\alpha}{1-(1-\alpha)\theta}-1} > 0$$

and

$$\frac{\partial^2 \bar{h}_t}{\partial \left(k_t\right)^2} = -\left(1-\frac{\theta\alpha}{1-(1-\alpha)\theta}\right)\frac{\theta\alpha}{\left(1-(1-\alpha)\theta\right)} \times \left[\frac{1}{(n+\nu)}\right]^{\frac{1}{1-(1-\alpha)\theta}} C^{\frac{\theta}{1-(1-\alpha)\theta}} \left(k_t\right)^{\frac{\theta\alpha}{1-(1-\alpha)\theta}-2} < 0$$

By exploiting these results we obtain the phase diagram contained in Figure 1.2.

Figure 1.2: The phase diagram

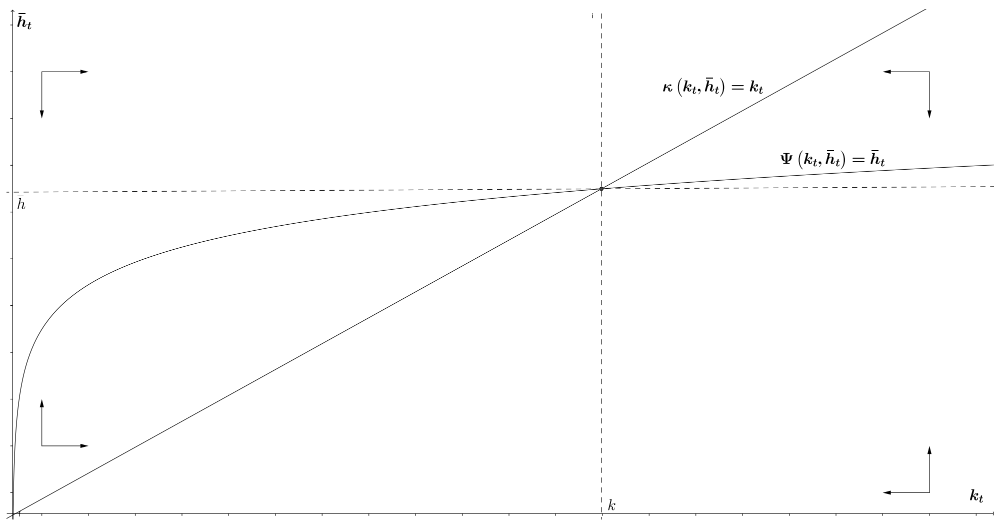



Figure 1.2 illustrates exactly the convergence of the system (1.23)-(1.24) to the steady-state characterized by the couple $\left\{k; \bar{h}\right\}$. At this steady-state, by substituting $w_t$ and $(1+r_t)$ by respectively equations (1.15) and (1.16) and by applying $k_t = k$ and $\bar{h}_t = \bar{h}$ in equations (1.9), (1.10), (1.12) and (1.13) we obtain:

$$c^1_{D,h} = \frac{\phi(1-\alpha)}{(1+\beta)\left(\gamma_h(1-\phi)+\phi\right)} k^\alpha \bar{h}^{1-\alpha} \tag{1.31}$$

$$m^1_{D,h} = \frac{\gamma_h(1-\phi)(1-\alpha)}{(1+\beta)\left(\gamma_h(1-\phi)+\phi\right)} k^\alpha \bar{h}^{1-\alpha} \tag{1.32}$$

$$c_{D,h}^2 = \frac{\phi\alpha(1+n)}{(\phi+\gamma_h(1-\phi))}k^{\alpha}\bar{h}^{(1-\alpha)} \tag{1.33}$$

$$m_{D,h}^2 = \frac{\gamma_h\alpha(1-\phi)(1+n)}{(\phi+\gamma_h(1-\phi))}k^{\alpha}\bar{h}^{(1-\alpha)} \tag{1.34}$$

$$c_{D,l}^1 = \frac{\phi(1-\alpha)}{(1+\beta)(\gamma_l(1-\phi)+\phi)}k^{\alpha}\bar{h}^{1-\alpha} \tag{1.35}$$

$$m_{D,l}^1 = \frac{\gamma_l(1-\phi)(1-\alpha)}{(1+\beta)(\gamma_l(1-\phi)+\phi)}k\bar{h}^{1-\alpha} \tag{1.36}$$

$$c_{D,l}^2 = \frac{\phi\alpha(1+n)}{(\phi+\gamma_l(1-\phi))}k^{\alpha}\bar{h}^{(1-\alpha)} \tag{1.37}$$

$$c_{D,l}^2 = \frac{\gamma_l\alpha(1-\phi)(1+n)}{(\phi+\gamma_l(1-\phi))}k^{\alpha}\bar{h}^{(1-\alpha)} \tag{1.38}$$

Equations (1.31), (1.32), (1.33), (1.34), (1.35), (1.36), (1.37) and (1.38) provide the optimal amounts allocated to consumption and health spending by healthy and unhealthy households when economy reaches its non-trivial steady-state. These also equations illustrate the resource allocation between each household at the steady-state when the economy is decentralized. In equations (1.31), (1.32), (1.33), (1.34), (1.35), (1.36), (1.37) and (1.38), the subscript $D$ designates the decentralized solution. It follows that $c_{D,h}^1$ indicates the optimal amount allocated to consumption by young household of type $h$ in decentralized economy.

However, as indicated in Section 1.1.2, this decentralized allocation is characterized for unhealthy households by higher health spending and lower consumption expenditures compared to those of healthy households (see Proposition 2). This unequal trade-off between health spending and consumption between healthy and unhealthy households is mainly explained by difference in returns to health spending as quality of life between the two types of households as $0 < \gamma_h < \gamma_l < 1$. It seems then that decentralized allocation fails to allocate the same amount to health expenditure and consumption between each type of household.

## 1.5 Social Optimum

Another way to allocate the resources between each type of household is to plan allocation. To achieve this planned resource allocation, let a benevolent central planner ensures an efficient allocation of available resource between each household. The aim of this central planner is to maximize the social welfare $\mathcal{W}$ defined as the weighted sum of all households' well-being at each period subject to resource constraint.

The solution of central planner's problem is defined as social optimum solution. When the economy reaches its non-trivial steady-state, the long run social optimum solution characterizes the solution of central planner's problem. Could then the long run social optimum solution be better than decentralized allocation for each type of household ? Could the central planner take into account the difference in returns of health spending as quality of life between the two types of households during the allocation process ? To answer these questions, we analyze the long run social optimum solution of our model.

Let $\mathcal{W}$ the social welfare such that:

$$\begin{aligned}\mathcal{W} = & \sum_{i=h,l} \phi \log c^1_{FB,i} + \sum_{i=h,l} \gamma_i (1-\phi) \log m^1_{FB,i} \\ & + \frac{\beta}{1+n} \left[ \sum_{i=h,l} \phi \log c^2_{FB,i} + \sum_{i=h,l} \gamma_i (1-\phi) \log m^2_{FB,i} \right]\end{aligned}$$

$c^1_{FB,i}$ indicates the consumption of young household of type $i$ and $m^1_{FB,i}$ describes its health spending. $c^2_{FB,i}$ designates the consumption of retired household of type $i$ and $m^2_{FB,i}$ illustrates its expenditures on health. The subscript $FB$ indicates the optimal solution in this centralized economy.

The resource constraint of central planner is such that:

$$\frac{(1+\beta\alpha)}{(1+\beta)} k^\alpha \bar{h}^{1-\alpha} = \sum_{i=h,l} c^1_{FB,i} + \frac{1}{1+n} \sum_{i=h,l} c^2_{FB,i} + \sum_{i=h,l} m^1_{FB,i} + \frac{1}{1+n} \sum_{i=h,l} m^2_{FB,i} \quad (1.39)$$

as by definition, the available resource in economy is given by $y - (1+n)\,k$ with:

$$y = k^{\alpha}\bar{h}^{1-\alpha} \qquad \text{and} \qquad k = \frac{\beta\,(1-\alpha)}{(1+n)\,(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha}$$

The benevolent central planner's problem is then:

$$\begin{cases} Max\ \mathcal{W} = \sum\limits_{i=h,l}\phi\log c^{1}_{FB,i} + \sum\limits_{i=h,l}\gamma_i\,(1-\phi)\log m^{1}_{FB,i} \\ \qquad + \frac{\beta}{1+n}\left[\sum\limits_{i=h,l}\phi\log c^{2}_{FB,i} + \sum\limits_{i=h,l}\gamma_i\,(1-\phi)\log m^{2}_{FB,i}\right] \\ s.t \quad \frac{(1+\beta\alpha)}{(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha} = \sum\limits_{i=h,l}c^{1}_{FB,i} + \frac{1}{1+n}\sum\limits_{i=h,l}c^{2}_{FB,i} + \sum\limits_{i=h,l}m^{1}_{FB,i} + \frac{1}{1+n}\sum\limits_{i=h,l}m^{2}_{FB,i} \end{cases}$$

Let $\mathcal{L}$ the Lagrangian of this problem such that:

$$\begin{aligned} \mathcal{L} &= \sum_{i=h,l}\phi\log c^{1}_{FB,i} + \sum_{i=h,l}\gamma_i\,(1-\phi)\log m^{1}_{FB,i} \\ &+ \frac{\beta}{1+n}\left[\sum_{i=h,l}\phi\log c^{2}_{FB,i} + \sum_{i=h,l}\gamma_i\,(1-\phi)\log m^{2}_{FB,i}\right] \\ &+ \lambda\left(\frac{(1+\beta\alpha)}{(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha} - \sum_{i=h,l}c^{1}_{FB,i} - \frac{1}{1+n}\sum_{i=h,l}c^{2}_{FB,i} - \sum_{i=h,l}m^{1}_{FB,i} - \frac{1}{1+n}\sum_{i=h,l}m^{2}_{FB,i}\right) \end{aligned}$$

The FOC of this problem provide the following relationship:

$$c^{1}_{FB,h} = \frac{\phi}{\beta\gamma_l\,(1-\phi)}m^{2}_{FB,l} \tag{1.40}$$

$$m^{1}_{FB,h} = \frac{\gamma_h}{\beta\gamma_l}m^{2}_{FB,l} \tag{1.41}$$

$$c^{2}_{FB,h} = \frac{\phi}{\gamma_l\,(1-\phi)}m^{2}_{FB,l} \tag{1.42}$$

$$m^{2}_{FB,h} = \frac{\gamma_h}{\gamma_l}m^{2}_{FB,l} \tag{1.43}$$

$$c^{1}_{FB,l} = \frac{\phi}{\beta\gamma_l\,(1-\phi)}m^{2}_{FB,l} \tag{1.44}$$

$$m^1_{FB,l} = \frac{1}{\beta} m^2_{FB,l} \tag{1.45}$$

$$c^2_{FB,l} = \frac{\phi}{\gamma_l (1-\phi)} m^2_{FB,l} \tag{1.46}$$

The next proposition follows.

**Proposition 13** *To achieve the long run social optimum, the benevolent central planner allocates the same amount for consumption to households of type $l$ and $h$ of a given generation (see equations (1.40) and (1.44) and equations (1.42) and (1.46)). However, for the same generation, central planner devotes more resources to households of type $l$ than those of type $h$ as regards to health expenditures (see equations (1.41) and (1.45) and equation (1.43)).*

**Proof 10** *As $\gamma_l > \gamma_h$, it follows that:*

$$m^1_l = \frac{\gamma_l}{\gamma_h} m^1_{FB,h} > m^1_{FB,h}$$

*Moreover, as $\gamma_l > \gamma_h$, $m^2_{FB,l} > m^2_{FB,h}$ also.*

At individual level, $\gamma_l > \gamma_h$ determines the heterogeneity between healthy and unhealthy households and explains why households of type $l$ spend more on health than households of type $h$ (see Section 1.1.1). At social level, $\gamma_l > \gamma_h$ is internalized by the benevolent central planner. To compensate this biological inequality between healthy and unhealthy households, the benevolent central planner grants then much more weight to life quality of unhealthy households in $\mathcal{W}$ compared to the one of healthy households. Thus, to maximize the social welfare, the central planner allocates much more resources to households of type $l$ for their health spending. And according to Proposition 13, these resources are more important than those devoted to health spending of households of type $h$.

Moreover, in social welfare, the weight of unhealthy households quality of life is also more important than the weight of consumption of all households, whatever their type. It involves that an efficient way to improve $\mathcal{W}$ is to increase the resources devoted to health spending of unhealthy households. Indeed, the social welfare obtained by devoting more resources to unhealthy households health spending is higher than social welfare resulting from more resources allocated to consumption. It seems then that planned allocation improves resources perceived by unhealthy households in order to maximize $\mathcal{W}$. Could this planned allocation be better than the decentralized allocation for unhealthy households and healthy ones ?

To answer this question, we compare consumption and health expenditures of each type of households in centralized economy and in decentralized one. In centralized economy, by combining the resource constraint of central planner and equations (1.40), (1.41), (1.42), (1.43), (1.44), (1.45) and (1.46), we obtain:

$$c^1_{FB,h} = \frac{\phi\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.47}$$

$$m^1_{FB,h} = \frac{\gamma_h\left(1+n\right)\left(1-\phi\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.48}$$

$$c^2_{FB,h} = \frac{\phi\beta\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.49}$$

$$m^2_{FB,h} = \frac{\gamma_h\beta\left(1+n\right)\left(1-\phi\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.50}$$

$$c^1_{FB,l} = \frac{\phi\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.51}$$

$$m^1_{FB,l} = \frac{\gamma_l\left(1+n\right)\left(1-\phi\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.52}$$

$$m^2_{FB,l} = \frac{\beta\gamma_l\left(1+n\right)\left(1-\phi\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.53}$$

$$c^2_{FB,l} = \frac{\phi\beta\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^\alpha\bar{h}^{1-\alpha} \tag{1.54}$$

The next proposition follows.

**Proposition 14** *Assuming that $\gamma_l = 1-\gamma_h$, centralized allocation is better than decentralized one for all households whatever their type and their generation if and only* *if* $\bar{\alpha} > \alpha$ *and* $\gamma_h \in ]\hat{\gamma}_h, \tilde{\gamma}_h[$ *with:*

$$\bar{\alpha} = \frac{1+n+2\beta}{2(1+n)+(3+n)\beta}$$

$$\hat{\gamma}_h = \frac{1}{(1-\phi)} - \frac{\alpha(1+n+\beta)(1+\phi)(1+\beta)}{\beta(1+\beta\alpha)(1-\phi)}$$

*and*

$$\tilde{\gamma}_h = \frac{\alpha(1+n+\beta)(1+\beta)(1+\phi)}{\beta(1+\beta\alpha)(1-\phi)} - \frac{\phi}{(1-\phi)}$$

**Proof 11** *See Appendix B.*

According to Proposition 14, central planner is able to allocate more resources - to each type of household whatever its generation - in centralized economy than in decentralized one. This configuration occurs if $\bar{\alpha} > \alpha$ and if $\gamma_h \in ]\hat{\gamma}_h, \tilde{\gamma}_h[$. On one side, if these conditions are verified, central planner devotes much more resources to unhealthy households health spending (see Proposition 13) such that these resources are higher than the amount allocated by these households to their health spending in decentralized economy. On the other side, much more resources to unhealthy households health spending does not imply far less resources to healthy households health spending and consumption. Indeed, central planner also manages to increase the resources devoted to healthy households. It implies that, if $\bar{\alpha} > \alpha$ and if $\gamma_h \in ]\hat{\gamma}_h, \tilde{\gamma}_h[$, central planner's solution is better than decentralized configuration. Under these conditions, the biological inequality between healthy and unhealthy households is offset by central planner and resources perceived by each household are upgraded. However, centralized allocation could be worse than decentralized one if $\gamma_h \notin ]\hat{\gamma}_h, \tilde{\gamma}_h[$. That is why the trade-off between healthy and unhealthy households depends on level of $\gamma_h$.

At the household level, as underlined in Proposition 7, high level of $\gamma_h$ incites households of type $h$ to devote more resources to health spending. At the social level, high level of $\gamma_h$ upgrades the weight of healthy households quality of life in social welfare. It implies that higher $\gamma_h$ increases the resources allocated by central planner to healthy households. However, if $\gamma_h$ is enough high, the rise in resources allocated to healthy households health expenditures decreases the resources devoted to other type of household. This explains why resources perceived by some households could be less in centralized economy than in decentralized one if $\gamma_h > \tilde{\gamma}_h$. That is why centralized allocation is better than decentralized one for all households whatever their type and generation if $\tilde{\gamma}_h > \gamma_h$.

At the opposite, low value of $\gamma_h$ involves high value of $\gamma_l$ as we suppose for the sake of simplicity that $\gamma_l = 1 - \gamma_h$. It implies that high level of $\gamma_l$ upgrades the weight of unhealthy households quality of life in social welfare. Under this configuration, so as to maximize the social welfare, central planner increases the resources devoted to unhealthy households health spending. However, more resources to households of type $l$ health spending could diminish the resources allocated to other households. And this configuration occurs if $\hat{\gamma}_h > \gamma_h$ according to Proposition 14. This explains why centralized allocation provides more resources than decentralized one for all households whatever their type and generation if $\gamma_h > \tilde{\gamma}_h$. That is why the range of $\gamma_h$ ensuring that centralized economy allocates more resources than decentralized economy belongs to $\hat{\gamma}_h$ and $\tilde{\gamma}_h$.

The additional condition to verify that centralized allocation is better than decentralized one is $\bar{\alpha} > \alpha$. $\alpha$ indicates the elasticity of substitution between physical capital stock and efficient labor (see production function). Moreover, due to the usual assumptions on the production function, $\alpha$ also measures the share of capital in total income. Higher is $\alpha$, higher are resources devoted to remunerate the physical capital stock and lower are resources allocated to households consumption and health spending. This configuration occurs if $\alpha > \bar{\alpha}$ and implies that centralized allocation is worse than decentralized one for all households. That is why resources allocated in centralized economy are higher than those in decentralized one if $\bar{\alpha} > \alpha$.

## 1.6 Conclusion

This chapter provides a theoretical framework in which health spending devoted to improve the life quality generate a positive externality that affects positively labor productivity. For that purpose, we develop a two-period OLG model in which households make health expenditures to improve their quality of life. Two types of households coexist: the ones with poor health and those with good health. Healthy households are characterized by higher returns to health spending as quality of life than unhealthy households. Moreover, we assume that the current size of healthy households in population is driven by the positive externality resulting from health expenditures made by this type of household at the previous period. The share of young healthy households in young generation is thereafter used to approximate the overall health level in economy. The overall health affects positively the efficiency of labor supply. Thus, through this mechanism, we demonstrate that an intergenerational transmission of life quality occurs and allows to increase labor productivity.

It is also shown that positive externality resulting from health expenditures does not disturb the ability of this decentralized economy to converge to its non-trivial steady-state. However, this non-trivial steady-state is characterized by a difference in trade-off between consumption and health spending between healthy and unhealthy households. This difference in trade-off is mainly explained by a difference in rate of returns of health expenditures between the two types of households. In centralized economy, this difference disappears and we demonstrate that there is a configuration in which centralized allocation is better than a decentralized one.

Thus, we described through this chapter how a positive externality resulting from health spending intended to improve the quality of life affects positively labor productivity. The externality channel is then another way through which the positive effect of health expenditures on labor productivity can occur.

# Appendix of Chapter 1

## A. The optimal solutions of central planner's problem

The relationship obtained through the FOC of central planner's problem are described by equations (1.40), (1.41), (1.42), (1.43), (1.44), (1.45) and (1.46). By plugging these relationship in equation (1.39), the expression of resource constraint becomes:

$$\frac{(1+\beta\alpha)}{(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha} = \frac{(1+n+\beta)\left(2\phi+(\gamma_h+\gamma_l)(1-\phi)\right)}{\beta\gamma_l(1+n)(1-\phi)}m^2_{FB,l}$$

After simplification, the previous expression implies that:

$$m^2_{FB,l} = \frac{\beta\gamma_l(1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)\left(2\phi+(\gamma_h+\gamma_l)(1-\phi)\right)(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha}$$

Thus, the relationship highlighted by equations (1.40), (1.41), (1.42), (1.43), (1.44), (1.45) and (1.46) allows to deduce $c^1_{SB,h}$ (equation 1.47), $m^1_{SB,h}$ (equation 1.48), $c^2_{SB,h}$ (equation 1.49), $m^2_{SB,h}$ (equation 1.50), $c^1_{SB,l}$ (equation 1.51), $m^1_{SB,l}$ (equation 1.52), $c^2_{SB,l}$ (equation 1.54) and $m^2_{SB,l}$ (equation 1.53).

## B. Proof of Proposition 14

### b.1. The healthy retired health spending

We have

$$m^2_{FB,h} = \frac{\gamma_h\beta(1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)\left(2\phi+(\gamma_h+\gamma_l)(1-\phi)\right)(1+\beta)}k^{\alpha}\bar{h}^{1-\alpha}$$

and

$$m^2_{D,h} = \frac{\gamma_h(1-\phi)\alpha(1+n)}{(\phi+\gamma_h(1-\phi))}k^{\alpha}\bar{h}^{(1-\alpha)}$$

It follows that $m^2_{FB,h} \geq m^2_{D,h}$ implies:

$$\frac{\gamma_h \beta (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\gamma_h (1-\phi)\alpha(1+n)}{(\phi+\gamma_h(1-\phi))} k^\alpha \bar{h}^{(1-\alpha)}$$

Namely, $m^2_{FB,h} \geq m^2_{D,h}$ involves:

$$\beta(1+\beta\alpha)(\phi+\gamma_h(1-\phi)) \geq \alpha(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)$$

For analytical convenience, we assume thereafter that $1=\gamma_l+\gamma_h$. Thus, by introducing this assumption in the previous inequality, we obtain:

$$m^2_{FB,h} \geq m^2_{D,h} \Leftrightarrow \beta(1+\beta\alpha)(\phi+\gamma_h(1-\phi)) \geq \alpha(1+n+\beta)(2\phi+(\gamma_h+1-\gamma_h)(1-\phi))(1+\beta)$$

After some simplification, we find that:

$$m^2_{FB,h} \geq m^2_{D,h} \Leftrightarrow \gamma_h \geq \frac{\alpha(1+n+\beta)(1+\beta)(1+\phi)}{\beta(1+\beta\alpha)(1-\phi)} - \frac{\phi}{(1-\phi)}$$

Let then:

$$\tilde{\gamma}_h = \frac{\alpha(1+n+\beta)(1+\beta)(1+\phi)}{\beta(1+\beta\alpha)(1-\phi)} - \frac{\phi}{(1-\phi)} \tag{1.55}$$

Thus, $m^2_{FB,h} \geq m^2_{D,h}$ if $\gamma_h \geq \tilde{\gamma}_h$.

### b.2. The healthy retired consumption

We have:

$$c^2_{FB,h} = \frac{\phi\beta(1+n)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$c^2_{D,h} = \frac{\phi\alpha(1+n)}{(\phi+\gamma_h(1-\phi))} k^\alpha \bar{h}^{(1-\alpha)}$$

It follows that $c^2_{FB,h} \geq c^2_{D,h}$ implies:

$$\frac{\phi\beta(1+n)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\phi}{(\phi+\gamma_h(1-\phi))} \alpha(1+n) k_t^\alpha \left(\bar{h}_t\right)^{(1-\alpha)}$$

Namely $c^2_{FB,h} \geq c^2_{D,h}$ involves:

$$\beta\left(1+\beta\alpha\right)\left(\phi+\gamma_h\left(1-\phi\right)\right) \geq \alpha\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)$$

For analytical convenience, we assume as previously that $1=\gamma_l+\gamma_h$. Thus, after some simplification, we find that like for healthy retired health spending, $c^2_{FB,h} \geq c^2_{D,h}$ if $\gamma_h \geq \tilde{\gamma}_h$.

### b.3. The healthy young consumption

We have:

$$c^1_{FB,h} = \frac{\phi\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)} k^{\alpha}\bar{h}^{1-\alpha}$$

and

$$c^1_{D,h} = \frac{\phi}{\left(1+\beta\right)\left(\gamma_h\left(1-\phi\right)+\phi\right)}\left(1-\alpha\right)\left(k_t\right)^{\alpha}\left(\bar{h}_t\right)^{1-\alpha}$$

It follows that $c^1_{FB,h} \geq c^1_{D,h}$ implies that:

$$\frac{\phi\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)} k^{\alpha}\bar{h}^{1-\alpha} \geq \frac{\phi}{\left(1+\beta\right)\left(\gamma_h\left(1-\phi\right)+\phi\right)}\left(1-\alpha\right)\left(k_t\right)^{\alpha}\left(\bar{h}_t\right)^{1-\alpha}$$

Namely, $c^1_{FB,h} \geq c^1_{D,h}$ involves:

$$c^1_{FB,h} \geq c^1_{D,h} \Leftrightarrow \left(1+n\right)\left(1+\beta\alpha\right)\left(\gamma_h\left(1-\phi\right)+\phi\right) \geq \left(1-\alpha\right)\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)$$

For analytical convenience, we assume as previously that $1=\gamma_l+\gamma_h$. Thus, by introducing this assumption in the previous inequality, we obtain:

$$c^1_{FB,h} \geq c^1_{D,h} \Leftrightarrow \gamma_h \geq \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)}$$

Let then:

$$\check{\gamma}_h = \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)} \tag{1.56}$$

It follows that $c^1_{FB,h} \geq c^1_{D,h}$ if $\gamma_h \geq \check{\gamma}_h$.

### b.4. The healthy young health spending

We have:

$$m^1_{FB,h} = \frac{\gamma_h (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi + (\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$m^1_{D,h} = \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)} k^\alpha \bar{h}^{1-\alpha}$$

It follows that $m^1_{FB,h} \geq m^1_{D,h}$ implies that:

$$\frac{\gamma_h (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi + (\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\gamma_h (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_h(1-\phi)+\phi)} k^\alpha \bar{h}^{1-\alpha}$$

Namely, $m^1_{FB,h} \geq m^1_{D,h}$ involves that:

$$(1+n)(1+\beta\alpha)(\gamma_h(1-\phi)+\phi) \geq (1-\alpha)(1+n+\beta)(2\phi + (\gamma_h+\gamma_l)(1-\phi))$$

For analytical convenience, we assume as previously that $1 = \gamma_l + \gamma_h$. Thus, after some simplification, we find that like for healthy young consumption, $m^1_{FB,h} \geq m^1_{D,h}$ if $\gamma_h \geq \check{\gamma}_h$.

### b.5. The unhealthy retired health spending

We have:

$$m^2_{FB,l} = \frac{\beta\gamma_l (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi + (\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$m^2_{D,l} = \frac{\gamma_l (1-\phi)\alpha(1+n)}{(\phi + \gamma_l(1-\phi))} k^\alpha \bar{h}^{(1-\alpha)}$$

It follows that $m^2_{FB,l} \geq m^2_{D,l}$ implies that:

$$\frac{\beta\gamma_l (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi + (\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\gamma_l (1-\phi)\alpha(1+n)}{(\phi + \gamma_l(1-\phi))} k^\alpha \bar{h}^{(1-\alpha)}$$

Namely, $m^2_{FB,l} \geq m^2_{D,l}$ involves that:

$$\beta\left(1+\beta\alpha\right)\left(\phi+\gamma_l\left(1-\phi\right)\right) \geq \alpha\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)$$

For analytical convenience, we assume as previously that $1 = \gamma_l + \gamma_h$. Thus, by introducing this assumption in the previous inequality, we obtain:

$$m^2_{FB,l} \geq m^2_{D,l} \Leftrightarrow \frac{1}{\left(1-\phi\right)} - \frac{\alpha\left(1+n+\beta\right)\left(1+\phi\right)\left(1+\beta\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)} \geq \gamma_h$$

Let then

$$\hat{\gamma}_h = \frac{1}{\left(1-\phi\right)} - \frac{\alpha\left(1+n+\beta\right)\left(1+\phi\right)\left(1+\beta\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)} \tag{1.57}$$

Thus, $m^2_{FB,l} \geq m^2_{D,l}$ if $\hat{\gamma}_h \geq \gamma_h$.

### b.6 The unhealthy retired consumption

We have:

$$c^2_{FB,l} = \frac{\phi\beta\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$c^2_{D,l} = \frac{\phi\alpha\left(1+n\right)}{\left(\phi+\gamma_l\left(1-\phi\right)\right)} k^\alpha \bar{h}^{(1-\alpha)}$$

It follows that $c^2_{FB,l} \geq c^2_{D,l}$ implies that:

$$\frac{\phi\beta\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\phi\alpha\left(1+n\right)}{\left(\phi+\gamma_l\left(1-\phi\right)\right)} k^\alpha \bar{h}^{(1-\alpha)}$$

Namely, $c^2_{FB,l} \geq c^2_{D,l}$ involves that:

$$\beta\left(1+\beta\alpha\right)\left(\phi+\gamma_l\left(1-\phi\right)\right) \geq \alpha\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)$$

For analytical convenience, we assume as previously that $1 = \gamma_l + \gamma_h$. Thus, after some simplification, we find that like for unhealthy retired health spending, $c^2_{FB,l} \geq c^2_{D,l}$ if $\hat{\gamma}_h \geq \gamma_h$.

### b.7. The unhealthy young health spending

We have:

$$m^1_{FB,l} = \frac{\gamma_l (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$m^1_{D,l} = \frac{\gamma_l (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_l(1-\phi)+\phi)} k^\alpha \bar{h}^{1-\alpha}$$

It follows that $m^1_{FB,l} \geq m^1_{D,l}$ implies that:

$$\frac{\gamma_l (1+n)(1-\phi)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha} \geq \frac{\gamma_l (1-\phi)(1-\alpha)}{(1+\beta)(\gamma_l(1-\phi)+\phi)} k^\alpha \bar{h}^{1-\alpha}$$

Namely, $m^1_{FB,l} \geq m^1_{D,l}$ involves that:

$$(1+n)(1+\beta\alpha)(1+\beta)(\gamma_l(1-\phi)+\phi) \geq (1-\alpha)(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)$$

For analytical convenience, we assume as previously that $1 = \gamma_l + \gamma_h$. Thus, by introducing this assumption in the previous inequality, we obtain:

$$m^1_{FB,l} \geq m^1_{D,l} \Leftrightarrow \frac{1}{(1-\phi)} - \frac{(1-\alpha)(1+n+\beta)(1+\phi)}{(1+n)(1+\beta\alpha)(1-\phi)} \geq \gamma_h$$

Let then:

$$\bar{\gamma}_h = \frac{1}{(1-\phi)} - \frac{(1-\alpha)(1+n+\beta)(1+\phi)}{(1+n)(1+\beta\alpha)(1-\phi)} \tag{1.58}$$

Thus, $m^1_{FB,l} > m^1_{D,l}$ if $\bar{\gamma}_h > \gamma_h$.

### b.8. The unhealthy young consumption

We have:

$$c^1_{FB,l} = \frac{\phi (1+n)(1+\beta\alpha)}{(1+n+\beta)(2\phi+(\gamma_h+\gamma_l)(1-\phi))(1+\beta)} k^\alpha \bar{h}^{1-\alpha}$$

and

$$c^1_{D,l} = \frac{\phi (1-\alpha)}{(1+\beta)(\gamma_l(1-\phi)+\phi)} k^\alpha \bar{h}^{1-\alpha}$$

It follows that $c^1_{FB,l} \geq c^1_{D,l}$ implies:

$$\frac{\phi\left(1+n\right)\left(1+\beta\alpha\right)}{\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)\left(1+\beta\right)}k^{\alpha}\bar{h}^{1-\alpha} > \frac{\phi\left(1-\alpha\right)}{\left(1+\beta\right)\left(\gamma_l\left(1-\phi\right)+\phi\right)}k^{\alpha}\bar{h}^{1-\alpha}$$

Namely, $c^1_{FB,l} \geq c^1_{D,l}$ involves:

$$\left(1+n\right)\left(1+\beta\alpha\right)\left(\gamma_l\left(1-\phi\right)+\phi\right) > \left(1-\alpha\right)\left(1+n+\beta\right)\left(2\phi+\left(\gamma_h+\gamma_l\right)\left(1-\phi\right)\right)$$

For analytical convenience, we assume as previously that $1 = \gamma_l + \gamma_h$. Thus, after some simplification, we find that, like for unhealthy young health spending, $c^1_{FB,l} \geq c^1_{D,l}$ if $\bar{\gamma}_h \geq \gamma_h$.

## b.9. The comparison of different values of $\gamma_h$

Previously, we found that:

$$\check{\gamma}_h = \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)}$$

and

$$\bar{\gamma}_h = \frac{1}{\left(1-\phi\right)} - \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)}$$

It follows that $\check{\gamma}_h > \bar{\gamma}_h$ implies:

$$\frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)} > \frac{1}{\left(1-\phi\right)} - \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)}$$

Namely, $\check{\gamma}_h > \bar{\gamma}_h$ involves:

$$\frac{1+n+2\beta}{\left(2\left(1+n\right)+\left(3+n\right)\beta\right)} > \alpha$$

Let then

$$\bar{\alpha} = \frac{1+n+2\beta}{2\left(1+n\right)+\left(3+n\right)\beta}$$

Thus, if $\bar{\alpha} > \alpha$ then $\check{\gamma}_h > \bar{\gamma}_h$.

Moreover, we find that:

$$\tilde{\gamma}_h = \frac{\alpha\left(1+n+\beta\right)\left(1+\beta\right)\left(1+\phi\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)}$$

and

$$\check{\gamma}_h = \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)}$$

It follows that $\tilde{\gamma}_h > \check{\gamma}_h$ implies:

$$\frac{\alpha\left(1+n+\beta\right)\left(1+\beta\right)\left(1+\phi\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)} > \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)} - \frac{\phi}{\left(1-\phi\right)}$$

Namely, $\tilde{\gamma}_h > \check{\gamma}_h$ involves that:

$$n > -\left(1 - \frac{\beta\left(1-\alpha\right)}{\alpha\left(1+\beta\right)}\right)$$

As $n > 0$, this condition is always verified. Thus, $\tilde{\gamma}_h > \check{\gamma}_h$

Furthermore, we find also that:

$$\hat{\gamma}_h = \frac{1}{\left(1-\phi\right)} - \frac{\alpha\left(1+n+\beta\right)\left(1+\phi\right)\left(1+\beta\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)}$$

and

$$\bar{\gamma}_h = \frac{1}{\left(1-\phi\right)} - \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)}$$

It follows that $\hat{\gamma}_h > \bar{\gamma}_h$ implies:

$$\frac{1}{\left(1-\phi\right)} - \frac{\alpha\left(1+n+\beta\right)\left(1+\phi\right)\left(1+\beta\right)}{\beta\left(1+\beta\alpha\right)\left(1-\phi\right)} > \frac{1}{\left(1-\phi\right)} - \frac{\left(1-\alpha\right)\left(1+n+\beta\right)\left(1+\phi\right)}{\left(1+n\right)\left(1+\beta\alpha\right)\left(1-\phi\right)}$$

Namely, $\hat{\gamma}_h > \bar{\gamma}_h$ involves

$$n < -\left(1 - \frac{\beta\left(1-\alpha\right)}{\alpha\left(1+\beta\right)}\right)$$

However, as $n > 0$, this condition can never be verified. We deduce then that $\bar{\gamma}_h > \hat{\gamma}_h$.

To summarize, if $\bar{\alpha} > \alpha$, $\check{\gamma}_h > \bar{\gamma}_h$, $\bar{\gamma}_h > \hat{\gamma}_h$ and $\tilde{\gamma}_h > \check{\gamma}_h$. We deduce that if $\bar{\alpha} > \alpha$, then $\tilde{\gamma}_h > \check{\gamma}_h > \bar{\gamma}_h > \hat{\gamma}_h$.

### b.10. The condition to obtain a better allocation in centralized economy

To summarize, all of these previous calculations demonstrate that:

- $c^2_{FB,h} > c^2_{D,h}$ if $\gamma_h > \tilde{\gamma}_h$
- $c^1_{FB,h} > c^1_{D,h}$ if $\gamma_h > \check{\gamma}_h$
- $m^1_{FB,h} > m^1_{D,h}$ if $\gamma_h > \check{\gamma}_h$
- $m^2_{FB,l} > m^2_{D,l}$ if $\hat{\gamma}_h > \gamma_h$
- $c^2_{FB,l} > c^2_{D,l}$ if $\hat{\gamma}_h > \gamma_h$
- $m^1_{FB,l} > m^1_{D,l}$ if $\bar{\gamma}_h > \gamma_h$
- $c^1_{FB,l} > c^1_{D,l}$ if $\bar{\gamma}_h > \gamma_h$

They show also that if $\bar{\alpha} > \alpha$ then $\tilde{\gamma}_h > \check{\gamma}_h > \bar{\gamma}_h > \hat{\gamma}_h$. Thus, by combining all of these results, we find that if $\bar{\alpha} > \alpha$ and if $\gamma_h \in ]\hat{\gamma}_h, \tilde{\gamma}_h[$ then $c^2_{FB,h} > c^2_{D,h}$, $c^1_{FB,h} > c^1_{D,h}$, $m^1_{FB,h} > m^1_{D,h}$, $m^2_{FB,l} > m^2_{D,l}$, $c^2_{FB,l} > c^2_{D,l}$, $m^1_{FB,l} > m^1_{D,l}$ and $c^1_{FB,l} > c^1_{D,l}$.

# Chapter 2

# Out-of-pocket expenditure on health and productivity of European elderly workers[1]

So as to investigate the potential effects of out-of-pocket expenditure on health (OOPE on health) on labor productivity, we develop in Section 2.1, a general equilibrium model with two overlapping generations: prime-age and old-age generations. Contrariwise to OLG model developed in Chapter 1, we assume here that all generations work at each period and supply an elastic labor. Moreover, health is not the only determinant of labor efficiency like in Chapter 1. We assume that labor efficiency depends on (i) manpower, (ii) labor in knowledge form and (iii) labor in health form determined by health status.

To establish the link between OOPE on health and labor productivity, we suppose that OOPE on health made during prime-age affects health status of old workers and then human capital in health form at old-age. OOPE on health is then considered as an investment expenditure determining labor efficiency of old workers. That is why prime-age generation has an incentive to make OOPE on health. Thus, by exploiting

[1]This Chapter is based on a joint work with Radmila DATSENKO and refers to Datsenko and Rabesandratana (2015)



this framework, we provide a microfounded relationship between OOPE on health made during prime-age and labor productivity at old-age. We check the empirical relevance of this relationship, in Section 2.2. For that purpose, we exploit the Survey of Health, Ageing and Retirement in Europe (SHARE) database. Our empirical results suggest that correlation between OOPE on health and old workers productivity is limited.

However, our empirical results are based on the two following assumptions: OOPE on health enhances health status of old workers (assumption 1) and health status affects positively labor productivity (assumption 2). Could then the weak correlation between OOPE on health and labor productivity be explained by the irrelevance of assumptions 1 and 2 ? To answer this question, in Section 2.3, we check the empirical relevance of these assumptions. Our empirical results suggest that, first, OOPE on health affects positively and significantly health status of senior workers. Second, there is a positive and significant correlation between labor productivity of elderly workers and their current state of health. Thus, according to these empirical evidences, the limited correlation between OOPE on health and the elderly workers productivity does not involve the irrelevance of assumptions 1 and 2. These results describe just the inability of OOPE on health to improve labor productivity.

This Chapter is organized as follow. In Section 2.1 we present the OLG model establishing the microfoundation of relationship between OOPE on health and elderly worker productivity. In Section 2.2.2, we check the empirical relevance of this relationship. In Section 2.3, we undertake some additional empirical analysis to verify the empirical consistency of our theoretical model. The Section 2.4 concludes.

## 2.1 The model

The general equilibrium model with overlapping generations *à la Diamond* allows to analyze the effects of individual decisions, taken at different stages of life, on (i) the individual behavior during the life cycle and (ii) the economic performance at the aggregate level, when different generations coexist. We exploit this framework to exhibit a microfounded relationship between OOPE on health made during prime-age and labor productivity at old-age. For that purpose, we assume that two generations coexist at each period: prime-age and old-age generations. Let $N_t$ and $N_{t-1}$ the size of respectively prime-age and old-age generations at time $t$ such that:

$$N_t = (1+n)N_{t-1}$$

with $n \geq 0$ the exogenous population growth rate.

Each generation is composed by heterogeneous agents $i$ who differ from each other by their ability to work. More precisely, we assume that each agent is able to supply labor in three various forms : manpower $l^t_{i,t}$, labor in health form $h_{i,t}$ and labor in knowledge form $e_{i,t}$. Manpower just represents the part of labor depending on time allocated to work. This part of labor is remunerated at wage rate $w^L_t$ and each agent cannot improve its quality. Following the literature on the positive effect of health on labor efficiency (Grossman (1972), Bloom, Canning, and Sevilla (2004), Aghion, Howitt, and Murtin (2011), Barro (2013b)), we consider the labor in health form as the part of labor depending qualitatively on health. This part of labor is remunerated at wage rate $w^H_t$. Finally, in the same line with the literature on the positive effect of skills/knowledge on labor efficiency (Mincer (1958); Arrow (1962); Ben-Porath (1967)), labor in knowledge form is assimilated to the part of labor determined by time allocated to education. This last part of labor is remunerated at wage rate $w^E_t$.

We assume that there is a given constant distribution of different agents $i \in I$ defined by a probability $\mu$ on the set $I$. It follows that, at time $t$, the aggregate manpower, the aggregate labor in health form and the aggregate labor in knowledge form are given respectively by $(N_{t-1}+N_t)\bar{l}_t$, $(N_{t-1}+N_t)\bar{h}_t$ and $(N_{t-1}+N_t)\bar{e}_t$ such that:

$$\begin{aligned}
(N_{t-1}+N_t)\bar{l}_t &= \int_I (N_{t-1}+N_t) l_{i,t} \mathrm{d}\mu(i) \\
(N_{t-1}+N_t)\bar{h}_t &= \int_I (N_{t-1}+N_t) h_{i,t} \mathrm{d}\mu(i) \\
(N_{t-1}+N_t)\bar{e}_t &= \int_I (N_{t-1}+N_t) e_{i,t} \mathrm{d}\mu(i)
\end{aligned}$$

### 2.1.1 The heterogeneous agent $i$

Each agent $i$ lives at best during two periods and is characterized by his additive separable intertemporal utility function $U_i$ such that:

$$U_i\left(c^t_{i,t}, d^t_{i,t}, c^t_{i,t+1}, d^t_{i,t+1}\right) = \ln c^t_{i,t} + \ln d^t_{i,t} + \beta\left[\ln c^t_{i,t+1} + \ln d^t_{i,t+1}\right] \tag{2.1}$$

His instantaneous felicity at each period then depends on his consumption $c$ and his time allocated to leisure $d$. At the second period, his utility is discounted by a psychological discount factor $\beta \in ]0;1[$.

The intertemporal utility function is subject to time and budget constraints. The time constraint during the first period is described as follows:

$$l^t_{i,t} + u^t_{i,t} + d^t_{i,t} = 1 \tag{2.2}$$

Namely, during the first period, agent has one time unit allocated to work ($l_{i,t}$), leisure ($d_{i,t}$) and schooling ($u_{i,t}$). During the second period, he always has one time unit shared between work participation ($l_{i,t+1}$) and leisure activities ($d_{i,t+1}$), namely

$$l^t_{i,t+1} + d^t_{i,t+1} = 1 \tag{2.3}$$

The budget constraints of agent $i$ at first and second periods are respectively:

$$w^L_t l^t_{i,t} + w^H_t h^t_{i,t} + w^E_t e^t_{i,t} = c^t_{i,t} + m^t_{i,t} + s^t_{i,t} \tag{2.4}$$

$$(1 + r_{t+1})s^t_{i,t} + w^L_{t+1} l_{i,t+1} + w^H_{t+1} h_{i,t+1} + w^E_{t+1} e_{i,t+1} = c^t_{i,t+1} \tag{2.5}$$

In other words, at the first period, agent $i$ supplies labor in three various forms and perceives $w^L_t l^t_{i,t} + w^H_t h^t_{i,t} + w^E_t e^t_{i,t}$ as total labor income. This labor income allows to consume $c^t_{i,t}$, spend $m^t_{i,t}$ as OOPE on health and save $s^t_{i,t}$. The returns on saving at the second period are given by $(1 + r_{t+1})s^t_{i,t}$ with $r_{t+1}$ the interest rate. At the second period, agent also supplies labor in three various forms and earns $w^L_{t+1} l_{i,t+1} + w^H_{t+1} h_{i,t+1} +$

$w^E_{t+1}e_{i,t+1}$. He uses his total income $(1+r_{t+1})s^t_{i,t} + w^L_{t+1}l_{i,t+1} + w^H_{t+1}h_{i,t+1} + w^E_{t+1}e_{i,t+1}$ to consume $c^t_{i,t+1}$.

Following Boucekkine, De la Croix, and Licandro (2003), the relationship between the labor in knowledge form at $t+1$ and the time allocated to schooling at time $t$ is given by:

$$e^t_{i,t+1} = \Omega \left(u^t_{i,t}\right)^\theta \tag{2.6}$$

$\theta \in ]0;1[$ and $\Omega > 0$ indicate respectively the rate of returns of the time of schooling and the overall level of knowledge in the economy. $\Omega$ can be assimilated to a scale parameter increasing the level of $e_{i,t+1}$. The labor in knowledge form is then just an increasing and concave function of time spent in education during the first period [2].

The relationship between labor in health form and OOPE on health is described as follows:

$$h^t_{i,t+1} = h^t_{i,t} \left(m^t_{i,t}\right)^\phi \tag{2.7}$$

with $\phi \in ]0;1[$ the rate of returns of OOPE on health. Following Grossman (1972), this specification implies that labor in health form is a stock variable depending on its previous level. However, unlike Grossman (1972), we assume no depreciation of $h^t_{i,t}$ between the two periods of agent's life. This strong assumption allows thereafter to assimilate $h^t_{i,t}$ to a scale parameter determining the level of $h^t_{i,t+1}$. Thus, by considering $h^t_{i,t}$ like a scale parameter, we can assume that each agent is endowed by the same level of $h^t_{i,t}$ at its birth. Each agent is not able to choose the optimal level of $h^t_{i,t}$ as this latter is given exogenously. As $h^t_{i,t}$ is assimilated to an exogenous parameter, any depreciation of $h^t_{i,t}$ just changes its level. Moreover, we neglect in equation (2.7) the influence of the other forms of health spending on labor in health form. $h^t_{i,t+1}$ only depends on the OOPE on health $m^t_{i,t}$ because we assimilate this latter as an individual private health spending unlike to private health expenditures reimbursed by health insurance.

Note that including health expenditures reimbursed by health insurance in equation (2.7) should not change the main result of model. To convince, let $G_t$ the health spend-

[2] According to equation (2.6) $\frac{\partial e^t_{i,t+1}}{\partial u^t_{i,t}} > 0$ but $\frac{\partial^2 e^t_{i,t+1}}{\partial (u^t_{i,t})^2} < 0$

ing reimbursed by health insurance. Including $G_t$ in labor in health form switches for example its expression to $h^t_{i,t+1} = h^t_{i,t} (G_t)^{1-\phi} \left(m^t_{i,t}\right)^{\phi}$[3] instead of equation (2.7). However, it is well known that all parameters determining $G_t$ are established by health insurance[4]. The institutional features of $G_t$ does not then allow to determine individually the optimal mix between $G_t$ and $m^t_{i,t}$ which could improve $h^t_{i,t+1}$ because each agent only controls $m^t_{i,t}$. It involves that each agent can assimilate $G_t$ as an exogenous amount allocated to him to upgrade $h^t_{i,t+1}$ and each agent chooses $m^t_{i,t}$ for a given $G_t$. $G_t$ is like a scale parameter which could be for example normalized to one, $G_t = 1$. Assuming that $G_t = 1$ implies that expression of labor in health form switches to equation (2.7), $h^t_{i,t+1} = h^t_{i,t} \left(m^t_{i,t}\right)^{\phi}$.

Thus, the agent's problem is:

$$\begin{cases} \underset{c^t_{i,t};d^t_{i,t};c^t_{i,t+1};d^t_{i,t+1}}{Max} U_i = \ln c^t_{i,t} + \ln d^t_{i,t} + \beta \left[\ln c^t_{i,t+1} + \ln d^t_{i,t+1}\right] \\ \text{subject to } (2.2), (2.3), (2.4), (2.5), (2.6), (2.7) \end{cases}$$

The first order conditions of this problem allow to determine the optimal level of each control variable (see Appendix A for more details). These optimal solutions then provide the exact expression of:

- the optimal time of schooling during the first period[5]:

$$u^t_{i,t} = \left(\frac{\Omega \theta w^E_{t+1}}{(1 + r_{t+1})\, w^L_t}\right)^{\frac{1}{1-\theta}} \tag{2.8}$$

- the optimal amount of OOPE on health:

$$m^t_{i,t} = \left(\frac{\phi h^t_{i,t} w^H_{i,t+1}}{(1 + r_{t+1})}\right)^{\frac{1}{1-\phi}} \tag{2.9}$$

[3]A meaningful way to introduce a relationship between the labor in health form, health spending reimbursed by the health insurance and the OOPE on health is to consider a Cobb-Douglas production function.

[4]The health insurance establishes the contribution rate and the repayment rate. That is why each agent isn't able to determine his optimal contribution and repayment rates.

[5]To obtain this result, the initial endowment in knowledge is normalized to unity for all agents, namely $e^t_{i,t} = 1$.

It follows that the exact expressions of labor in knowledge and health forms during the second period are given respectively by:

$$e^t_{i,t+1} = \Omega \left( \frac{\Omega \theta w^E_{t+1}}{(1 + r_{t+1})\, w^L_t} \right)^{\frac{1}{1-\theta}} \tag{2.10}$$

$$h^t_{i,t+1} = \left(h^t_{i,t}\right)^{\frac{1}{1-\phi}} \left( \frac{\phi w^H_{i,t+1}}{(1 + r_{t+1})} \right)^{\frac{\phi}{1-\phi}} \tag{2.11}$$

We can see that $w^L_t$ and the interest rate $r_{t+1}$ have negative effects on labor in knowledge form at the second period[6]. In contrast, an increase in $w^E_{t+1}$ motivates each agent to increase $u^t_{i,t}$ and improves thereafter $e_{i,t+1}$. Moreover, an increase in interest rate decreases $h_{i,t+1}$[7]. By cons, an increase in $w^H_{i,t+1}$ incites each agent to spend more in health during the first period $(\partial m^t_{i,t}/\partial w^H_{t+1} > 0)$ in order to rise $h^t_{i,t+1}$ thereafter.

### 2.1.2 The firm

The supply side of this model is characterized by a representative firm producing $Y_t$ at each period. Its technology is described by a neoclassical production function $F(K_t, T_t, E_t, H_t)$ such that:

$$Y_t = F(K_t, T_t, E_t, H_t) = (K_t)^\alpha (T_t)^\gamma (E_t)^\eta (H_t)^\rho \tag{2.12}$$

with

$$T_t = (L_{t-1} + L_t)\bar{l}_t \qquad E_t = (L_{t-1} + L_t)\bar{e}_t \qquad H_t = (L_{t-1} + L_t)\bar{h}_t$$

$T_t$, $E_t$ and $H_t$ indicate the demand from the firm for respectively manpower, labor in knowledge form and labor in health form. $K_t$ designates the physical capital used by

[6] An increase of $w^L_t$ motivates to reduce time allocated to education $\left(\partial u^t_{i,t}/\partial w^L_t < 0\right)$ and decreases $e_{i,t+1}$ during the second period.

[7] A rise of $r_{t+1}$ reduces the incentive to invest in health during the first period $(\partial m^t_{i,t}/\partial r_{t+1} < 0)$ and diminishes thereafter $h_{i,t+1}$.

the producer[8]. $\alpha$ , $\gamma$, $\eta$ and $\rho$ describe the elasticity of substitution of each factor with $\alpha \geq 0$, $\gamma > 0$, $\eta > 0$, $\rho > 0$ and $\alpha + \gamma + \eta + \rho = 1$. It involves that $F(K_t, T_t, E_t, H_t)$ respects all Inada's conditions.

The producer aims to maximize its profits $\Pi_t$ such that:

$$\Pi_t = p_t Y_t - (r_t + \delta) K_t - w_t^L T_t - w_t^E E_t - w_t^H H_t$$

As usual, we assume that the price of $Y_t$, namely $p_t$, is equal to unit because we consider $Y_t$ as a numeraire. For analytical convenience, we normalize the physical capital stock to one and assume that $\gamma + \eta + \rho = 1$. Including these assumptions in the first order conditions of producer's problem allows to deduce the following relationship (see Appendix B for more details):

$$w_t^L l_{i,t}^t = \gamma \left( l_{i,t}^t \right)^{\gamma} \left( e_{i,t}^t \right)^{\eta} \left( h_{i,t}^t \right)^{\rho} \tag{2.13}$$

$$w_t^E e_{i,t}^t = \eta \left( l_{i,t}^t \right)^{\gamma} \left( e_{i,t}^t \right)^{\eta} \left( h_{i,t}^t \right)^{\rho} \tag{2.14}$$

$$w_t^H h_{i,t}^t = \rho \left( l_{i,t}^t \right)^{\gamma} \left( e_{i,t}^t \right)^{\eta} \left( h_{i,t}^t \right)^{\rho} \tag{2.15}$$

Thus, the first order conditions of firm's problem imply that each factor is remunerated at its marginal productivity. Equations (2.13), (2.14) and (2.15) then indicate the amount paid by the representative firm to agent $i$ supplying $l_{i,t}$ unity of manpower, $e_{i,t}$ unity of labor in knowledge form and $h_{i,t}$ unity of labor in health form.

[8] As usual, $K_{t+1} = (1 - \delta) K_t + I_t$ describes the evolution of physical capital stock over time with $\delta \in \left]0, 1\right[$ the depreciation rate of $K_t$.

### 2.1.3 The equilibrium

As usual, the representative firm and the heterogeneous agents coordinate through the market mechanism. In addition, we assume that manpower market, market for labor in knowledge form, market for labor in health form, the goods market and the physical capital stock market operate without any friction.

*Thus, given a set of initial condition* $\{K_0; N_0\}$*, an equilibrium is a sequence of prices* $\{w_t^L; w_t^E; w_t^H; r_t\}_{t=0}^{t=\infty}$*, decision rules* $\{c_{i,t}^t; d_{i,t}^t; c_{i,t+1}^t; d_{i,t+1}^t\}_{t=0}^{t=\infty}$ *and quantities* $\{K_t, T_t, E_t, H_t, Y_t\}_{t=0}^{t=\infty}$ *such that for all* $t \geq 0$:

- *At period* $t$*, the agent* $i$ *chooses* $c_{i,t}^t; d_{i,t}^t; c_{i,t+1}^t; d_{i,t+1}^t$ *to solve the agent's problem taking prices as given*
- $w_t^L; w_t^E; w_t^H; r_t$ *give the remuneration of each factor*
- *the manpower market clears:* $(N_{t-1} + N_t)\bar{l}_t = T_t$
- *the market for labor in knowledge form clears:* $(N_{t-1} + N_t)\bar{e}_t = E_t$
- *the market for labor in health form clears:* $(N_{t-1} + N_t)\bar{h}_t = H_t$
- *the goods market clears:* $Y_t = C_t + C_{t-1} + M_t + S_t$
- *the physical capital stock market clears:* $K_{t+1} = S_t$

We exploit this general equilibrium framework to obtain the exact expression of labor productivity of each agent. Indeed, due to the general equilibrium, all markets clear. The markets clearing plus the first order conditions of producer's problem imply that firm remunerates each factor exactly at its marginal productivity. The productivity of $l_{i,t}^t$, $e_{i,t}^t$ and $h_{i,t}^t$ are then given respectively by $w_t^L l_{i,t}^t$, $w_t^E e_{i,t}^t$ and $w_t^H h_{i,t}^t$ with $w_t^L l_{i,t}^t + w_t^E e_{i,t}^t + w_t^H h_{i,t}^t$ the total labor productivity of agent $i$.

Let $w_t^L l_{i,t}^t + w_t^E e_{i,t}^t + w_t^H h_{i,t}^t$ the total labor income perceived by agent $i$ such that:

$$W_{i,t}^t = w_t^L l_{i,t}^t + w_t^E e_{i,t}^t + w_t^H h_{i,t}^t \tag{2.16}$$

and substitute $w_t^L l_{i,t}$, $w_t^E e_{i,t}$ and $w_t^H h_{i,t}$ in equation (2.16) by respectively equations (2.13), (2.14) and (2.15). We deduce the exact expression of total labor income and then the exact expression of labor productivity of agent $i$ at time $t$:

$$W_{i,t}^t = [\gamma + \eta + \rho] \left(l_{i,t}^t\right)^{\gamma} \left(e_{i,t}^t\right)^{\eta} \left(h_{i,t}^t\right)^{\rho} \tag{2.17}$$

It follows that:

$$W_{i,t+1}^t = [\gamma + \eta + \rho] \left(l_{i,t+1}^t\right)^{\gamma} \left(e_{i,t+1}^t\right)^{\eta} \left(h_{i,t+1}^t\right)^{\rho} \tag{2.18}$$

In addition, the general equilibrium implies that optimal solutions of agents' problem coincide with optimal solutions of firm's problem through the factor price. This feature of general equilibrium allows to substitute $h_{i,t+1}^t$ and $e_{i,t+1}$ in equation (2.18) by respectively equations (2.7) and (2.6). Thus, we find the exact expression of labor productivity of agent $i$ investing $m_{i,t}^t$ in health and allocating $u_{i,t}$ unity of time to schooling during the first period. This expression is given by:

$$W_{i,t+1} = [\gamma + \eta + \rho] \, \Omega^{\eta} \left(l_{i,t+1}\right)^{\gamma} \left(u_{i,t}\right)^{\theta\eta} \left(h_{i,t}\right)^{\rho} \left(m_{i,t}^t\right)^{\phi\rho} \tag{2.19}$$

As

$$\frac{\partial W_{i,t+1}}{\partial m_{i,t}^t} = \phi\rho \, [\gamma + \eta + \rho] \, \Omega^{\eta} \left(l_{i,t+1}\right)^{\gamma} \left(u_{i,t}\right)^{\theta\eta} \left(h_{i,t}\right)^{\rho} \left(m_{i,t}^t\right)^{\phi\rho - 1} > 0$$

we exhibit through equation (2.19) the positive effect of the previous OOPE on health on the current labor productivity.

## 2.2 The first empirical analysis

This Section is devoted to check the empirical relevance of the relationship between OOPE on health and labor productivity established in equation (2.19). For that purpose, and in line with our theoretical result, we assume that individual labor income is a good proxy to approximate the individual labor productivity. The relevance of this assumption is discussed in Section 2.2.1.1. Section 2.2.1.2 presents the benchmark empirical model used to undertake the empirical analysis. Data is also described in Section 2.2.2. Finally, Section 2.2.3 summarizes the empirical results.

## 2.2.1 The empirical strategy

### 2.2.1.1 Approximate labor productivity through the labor income

According to our theoretical model and following the class of general equilibrium model, by assuming that all markets are in perfect competition, there is a strict equality between wage income and labor productivity. However, it is well known that market competition, especially on labor market, is far for being perfect. Could then the equality between labor income and labor productivity still be valid without perfect competition ? To answer this question, Hellerstein, Neumark, and Troske (1999) (referred to below as HNT) test empirically this equality by exploiting US data set combining data on 120 000 workers and their employers within 3 000 firms. They estimate simultaneously (i) plant-level production function to assess the relative marginal productivity of groups of workers defined by sex, age, race and qualification and (ii) plant-level wage equations by aggregating individual-level earnings over workers employed in a plant. Their empirical results suggest that for most groups of workers, the estimated differentials between labor productivity and labor earning are very small. This result is similar to those of Hellerstein and Neumark (1995) who perform the same analysis on Israeli manufacturing. That is why they conclude that: "*the finding of equal changes in relative marginal productivity and relative wages with age is most consistent with the general human capital model of investment, in which wages rise in lockstep with productivity*".

Jones (2001) undertakes the same analysis as HNT to evaluate the productive nature of education in Ghana. For that purpose, she uses panel data of 200 manufacturing firms organized under the World Bank's Regional Programme for Enterprise Development (RPED) and collected during the summers of 1992, 1993, and 1994. Hers empirical results suggest that firms pay workers according to their productivity. The method developed by HNT is also applied by Aubert and Crépon (2003) on a matched French dataset of a yearly employee-level dataset[9] and a yearly firm-level dataset[10]. Aubert and Crépon (2003) estimate that the age-productivity profile is similar to the age-labor cost profile. Van Biesebroeck (2011) performs the same study as HNT by using matched employer-employee data from the manufacturing sector of three sub-Saharan countries which are Tanzania, Kenya, and Zimbabwe in three consecutive years between 1992 and 1995. He finds that in Zimbabwe, all wage premiums associated with each human capital characteristics[11] match the productivity gains that are associated with them. In other countries, his results suggest that the gap between wage premiums and productivity is small. Strauss and Wohar (2004) investigate the long-run relationship between real wages and average labor productivity at the industry level for a panel of 459 US manufacturing industries over the period 1956-1996. They estimate the cointegration between the panel of labor productivity and the panel real wages. Their results suggest that many (but not all) individual industries support a cointegrating relationship between labor productivity and real wages. In other words, according to these authors, there is a stable long-run relationship between real wages and productivity for many but not all industries.

According to these empirical results, it seems that wage income could be used as a proxy of labor productivity despite of imperfect competition on labor market. Obviously, these empirical evidences do not highlight a perfect equality between labor productivity and labor earning but they also fail to reject unambiguously this equality. According to Feldstein (2008), the gap between labor income and labor productivity, observed in all studies using the HNT's method, is due to two statistical measurement errors. The first one is a focus on wages rather than total compensation. He then suggest to compare the productivity rise with the increase of total compensation rather than with the increase of the narrower measure of just wages and salaries. The second error is the non-use of two different deflators, one for measuring productivity and the

[9]The yearly employee-level dataset is Déclarations Administratives de Données Sociales (DADS)
[10]The yearly firm-level dataset is Bénéfices Réels Normaux (BRN) which contains information on 70,000 firms during the 1994-2000
[11]The human capital characteristics retained by Van Biesebroeck (2011) are experience, schooling, job tenure, and training.

other for measuring real compensation. This implies that the real marginal product of labor should be compared to the wage deflated by the product price and not by some consumer price index. The empirical result of this author then suggests that by correcting these errors, the rise in compensation has been very similar to the rise in productivity[12].

Thus, there is strong empirical relevances allowing to consider labor income as a good proxy of labor productivity. By relying on these empirical evidences, we perform our empirical analysis by approximating the individual productivity in equation (2.19) by the wage income.

#### 2.2.1.2 The role of gender and job occupation

To undertake an empirical analysis consistent with our theoretical result summarized in equation (2.19), we consider the effect of the three main determinants of human capital, namely (i) the manpower ($l_{i,t+1}$), (ii) the time allocated to schooling ($u_{i,t}$) and (iii) the previous health status ($h_{i,t}$). However, by taking into account only the effects of $l_{i,t+1}$, $u_{i,t}$ and $h_{i,t}$ on labor productivity, equation (2.19) fails to integer the effects of other individual variables. Empirical results obtained by estimating equation (2.19) could then be biased if we omit these variables. To offset this bias, and in the same line with empirical literature on the individual determinant of productivity, we include two additional variables in equation (2.19). These variables are gender and job occupation.

According to Hellerstein, Neumark, and Troske (1999) men and women have not the same productivity. *Ceteris paribus*, Hellerstein, Neumark, and Troske (1999) estimate that men produce more than women. We then control our estimation for gender difference by augmenting equation (2.19) by a dummy variable denoted by *Gender* such that $Gender = 0$ for men and $Gender = 1$ for women. Moreover, as we approximate labor productivity through labor income, control for gender allows also to consider the well-known wage inequality between men and women workers. In addition, we control

[12]Feldstein (2008) obtains this result by using American official productivity data available from 1947 to 2006.

for job occupation of each worker as labor productivity varies with job occupation (Gobel and Zwick 2012). Indeed, *ceteris paribus*, worker having a physical demanding job produces less than worker having no physical demanding job. To control for job occupation, we introduce the dummy variable $PDJ$[13] in equation (2.19). $PDJ = 0$ if job is not physically demanding and $PDJ = 1$ otherwise. Thus, we deduce the following empirical model:

$$\begin{aligned} \ln W_{i,t+1} &= a + a_1 \ln (l_{i,t+1}) + a_2 \ln (u_{i,t}) + a_3 \ln (h_{i,t}) \\ &\quad + a_4 \ln \left( m_{i,t}^t \right) + a_5 Gender + a_6 PDJ + \varepsilon_1 \end{aligned} \tag{2.20}$$

Equation 2.20 is just the log-linearized expression of equation (2.19) augmented by $Gender$ and $PDJ$ variables. It implies that, $a = \ln [\gamma + \eta + \rho]$, $a_1 = \gamma$, $a_2 = \theta\eta$, $a_3 = \rho$ and $a_4 = \phi\rho$. Based on the previous discussion, we expect that the sign of $a_1$, $a_2$, $a_3$ and $a_4$ are positive unlike to the sign of $a_5$ and $a_6$.

### 2.2.2 The data

Database exploited to estimate equation (2.20) is the Survey of Health, Ageing and Retirement in Europe (referred to below as SHARE). This is a cross-national panel database of micro data on health, socio-economic status, and social and family networks of more than 85.000 non-institutionalized population aged 50 and older in 19 European countries[14].

Four different waves typeset this database and provide a panel structure to SHARE[15]. Unfortunately, it is not possible to follow all individuals in 19 countries between the wave 1 (W1) and the wave 4 (W4). The number of countries composing SHARE varies

[13]PDJ means Physically Demanding Job

[14]The 19 European countries which compose SHARE database are Austria, Belgium, Czechia, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Netherlands, Poland, Portugal, Slovenia, Spain, Sweden and Switzerland.

[15]The first, second, third and fourth waves of collecting data have occurred respectively in 2004, 2006-2007, 2008-2009 and 2010-2011. Of course, a part of the sample was refreshed in the Waves 2 and 4 but this refreshment doesn't distort the longitudinal dimension of the database.

also across waves[16]. Moreover, most information in W3 are not comparable to those from the other waves as W3 focuses on information about individual living condition by adopting a retrospective view.

Despite of these caveats, SHARE provides a tractable sample to undertake our empirical analysis. The sample's design is consistent with our empirical model. Indeed, the estimation of equation 2.20 requires to obtain information on individuals at two different periods and SHARE provides these information. We then exploit W2 of SHARE to obtain information on each individual at time $t$ and W4 of SHARE provides information on the same individuals at time $t+1$[17]. It implies that time $t$ and $t+1$ correspond respectively to period 2006-2007 and 2010-2011 in our database.

As number of countries composing SHARE differs across waves, number of individuals in SHARE also varies from W2 to W4. To obtain a representative sample, we select only 12 countries among 19 European countries. Our sample then consists in 3,609 individuals who are in job in W2 and W4, and living in *Austria, Belgium, Czechia, Denmark, France, Germany, Italy, Netherlands, Poland, Spain, Sweden and Switzerland* between 2006-2007 and 2010-2011. Thus, our sample is designed correctly to estimate equation (2.20). The breakdown of this sample is indicated in Table 2.1.

Table 2.1: Breakdown of SHARE's sample in W2 and W4

| | | Job situation between W2 & W4 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Countries in W2 and W4 | Individuals in W2 & W4 | don't know (%) | retired (%) | employed or self-employed (%) | unemployed (%) | permanently sick or disables (%) | homemaker (%) | other (%) |
| Austria | 671 | 0.30 | 75.95 | 9.53 | 0.45 | 0.30 | 12.10 | 1.36 |
| Belgium | 2143 | 0.05 | 61.02 | 16.17 | 3.67 | 3.67 | 13.93 | 1.48 |
| Czechia | 1305 | - | 79.72 | 16.77 | 1.40 | 1.17 | 0.39 | 0.55 |
| Denmark | 1708 | 0.06 | 57.49 | 33.53 | 2.08 | 4.58 | 0.48 | 1.78 |
| France | 1889 | 0.05 | 68.90 | 20.55 | 2.01 | 1.85 | 5.93 | 0.71 |
| Germany | 1372 | - | 64.04 | 22.24 | 2.72 | 2.28 | 7.58 | 1.10 |
| Italy | 2006 | - | 61.46 | 12.93 | 1.35 | 2.60 | 20.57 | 1.10 |
| Netherlands | 1638 | - | 51.54 | 23.69 | 1.55 | 5.38 | 16.08 | 2.16 |
| Poland | 1507 | - | 71.23 | 11.63 | 3.26 | 7.84 | 2.59 | 3.46 |
| Spain | 1426 | 0.07 | 45.61 | 13.95 | 4.04 | 4.25 | 30.38 | 1.70 |
| Sweden | 1588 | - | 69.98 | 26.70 | 0.89 | 1.72 | 0.51 | 0.19 |
| Switzerland | 1045 | - | 54.18 | 34.44 | 0.78 | 1.26 | 8.85 | 0.49 |
| Total | 18298 | 0.03 | 62.80 | 20.21 | 2.14 | 3.28 | 10.17 | 1.36 |

Source: SHARE Wave 2 and Wave 4

[16] 11 countries take part to W1. 15 countries contribute to Wave 2 (W2) and Wave 3 (W3). And 4 additional countries participate to Wave 4 (W4).

[17] As W3 contains information which are different to those in other waves, we can't include W3 in the sample. Moreover, to obtain a correct sample size, we exclude also W1 from the sample. Most of individuals in W1 aren't include in W4. Including W1 could then reduce significantly the sample size.

SHARE database also provides information on manpower $(l^t_{i,t+1})$, time allocated to schooling $(u_{i,t})$, the amount of OOPE on health $(m^t_{i,t})$ and the previous labor in health form $(h^t_{i,t})$.

**The manpower** We approximate manpower by total hours worked per week by each worker. Obviously, this variable differs across countries as labor legislation is not the same in the 12 countries. Note that total hours worked per week ranges between 30 hours and 40 hours in our database.

**The time allocated to schooling** We estimate the time allocated to schooling by years of education. Years of education of a given worker vary between 0 year to 25 years in our sample.

**The amount of out-of-pocket expenditure on health** Each wave of SHARE provides information on OOPE on *inpatient care, outpatient care, prescribed drugs, nursing home, day-care and home-care.* To estimate equation (2.20), we then exploit information on these expenditures in W2. By making the sum of these OOPE, we obtain the exact amount of OOPE on health paid by each agent during 2006-2007[18]. Table 2.2 illustrates the OOPE on health distribution between 2006-2007.

**The previous labor in health form** We approximate the previous labor in health form by workers health status at the previous period. To obtain information on the previous health status of each individual, we exploit the great variety of information on individual health provided by SHARE. We keep this great variety of information on health to respect its multidimensional aspect. However, for econometric convenience, we synthesize all of these information on individual health into a single health score by using the Multiple Correspondence Analysis (referred to below as MCA) (Greenacre

[18]As we don't analyze the effect of having health insurance on labor productivity, we don't include in our empirical estimations any information on individual's contribution to health insurance or about transfers received from health insurance. Moreover, the enquiry about contribution (conversely transfer) to (conversely from) public health insurance are misinformed in SHARE.

Table 2.2: OOPE on health distribution between 2006-2007

| Country | Average | Standard deviation | Max | Min | Sample size | D9 | Q3 | Median | Q1 | D1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Out-of-pocket for health spending (€) | | | | | | | | | |
| Austria | 179,2 | 660,6 | 5220 | 0 | 63 | 250 | 120 | 50 | 20 | 0 |
| Belgium | 266,0 | 877,3 | 12794 | 0 | 336 | 550 | 200 | 71,5 | 15 | 0 |
| Czechia | 998,1 | 1773,0 | 13500 | 0 | 214 | 2600 | 1200 | 300 | 0 | 0 |
| Denmark | 2235,3 | 8004,2 | 130075 | 0 | 558 | 5000 | 1500 | 500 | 0 | 0 |
| France | 76,3 | 283,1 | 3150 | 0 | 364 | 150 | 30 | 0 | 0 | 0 |
| Germany | 210,1 | 515,2 | 6160 | 0 | 299 | 489 | 170 | 70 | 20 | 0 |
| Italy | 476,4 | 2018,1 | 30300 | 0 | 256 | 950 | 370 | 100 | 9 | 0 |
| Netherlands | 132,9 | 658,0 | 10500 | 0 | 381 | 250 | 19 | 0 | 0 | 0 |
| Poland | 337,3 | 567,5 | 3700 | 0 | 172 | 1000 | 400 | 110 | 0 | 0 |
| Spain | 152,9 | 518,0 | 6000 | 0 | 197 | 400 | 60 | 15 | 0 | 0 |
| Sweden | 1929,8 | 3167,2 | 39000 | 0 | 416 | 3726 | 2525 | 1190 | 300 | 0 |
| Switzerland | 816,9 | 1857,1 | 17000 | 0 | 353 | 2172 | 800 | 275 | 0 | 0 |

Source: SHARE Wave 2, Authors' calculation
Note: D1, Q1, Q3 and D9 indicate respectively the first decile, the first quartile, the third quartile and the ninth decile
For example, according to the seventh column and the third line, 10% of individuals in Austria's sample spend more than 250 € in health

and Blasius 2006). For that purpose, we identify all health indicators in SHARE and check if some of them inform on the same diseases or the same pathologies. If so, we only choose the relevant health indicator. We then retain 23 health indicators in $W2$ on which we apply the MCA (see Appendix C for more details). Thus, we obtain an health score for each individual and provide a numerical value to $h^t_{i,t}$[19]. We also estimate $h^t_{i,t+1}$ by using the same methodology for the period 2010-2011. We provide an overview of the individual health score in Table 2.3.

Table 2.3: An overview of the individual health score

| Country | Average | Standard deviation | Max | Min | Sample size | D9 | Q3 | Median | Q1 | D1 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Health score | | | | | | | | | |
| Austria | 86,85 | 11,32 | 100 | 55,34 | 63 | 98,47 | 96,07 | 88,48 | 79,96 | 71,40 |
| Belgium | 86,43 | 10,68 | 100 | 45,78 | 336 | 96,51 | 94,66 | 89,12 | 81,03 | 72,23 |
| Czechia | 86,56 | 10,53 | 100 | 47,85 | 214 | 96,47 | 93,95 | 89,65 | 81,50 | 71,85 |
| Denmark | 90,21 | 10,06 | 100 | 32,90 | 558 | 100,00 | 97,27 | 92,82 | 86,31 | 76,69 |
| France | 85,11 | 11,53 | 100 | 31,93 | 364 | 96,35 | 93,95 | 88,47 | 78,74 | 69,87 |
| Germany | 83,98 | 13,05 | 100 | 29,96 | 299 | 98,47 | 94,35 | 87,71 | 75,83 | 63,97 |
| Italy | 87,49 | 11,00 | 100 | 32,87 | 256 | 98,47 | 95,40 | 90,23 | 83,42 | 71,63 |
| Netherlands | 88,35 | 9,51 | 100 | 36,26 | 381 | 98,47 | 95,50 | 90,39 | 84,27 | 75,74 |
| Poland | 83,46 | 13,41 | 100 | 30,98 | 172 | 96,07 | 92,90 | 87,67 | 77,17 | 64,84 |
| Spain | 88,26 | 11,96 | 100 | 21,45 | 197 | 97,88 | 96,07 | 92,29 | 84,24 | 73,34 |
| Sweden | 89,62 | 9,44 | 100 | 40,04 | 416 | 98,47 | 95,98 | 92,41 | 85,75 | 77,43 |
| Switzerland | 89,61 | 9,64 | 100 | 47,23 | 353 | 98,47 | 96,07 | 92,53 | 85,76 | 76,58 |

Source: SHARE Wave 4 & authors' calculations
Note: D1, Q1, Q3 and D9 indicate respectively the first decile, the first quartile, the third quartile and the ninth decile
For example, according to the seventh column and the third line, 10% of the sample population in Austria have a health indicator higher than 98,47

[19]The health score varies between 0 and 100 such that $h^t_{i,t} = 0$ relates the worst state of health and $h^t_{i,t} = 100$ indicates the best state of health.

### 2.2.3 The results

To sum up, our empirical analysis consists of estimating equation (2.20) by exploiting SHARE database *to measure the effect of OOPE on health made by elderly workers during 2006-2007 on their labor productivity during 2010-2011*. According to equation (2.20), the best way to evaluate this effect is to undertake a Log-Log regression. However, a large part of elderly workers in sample do not make any OOPE on health during 2006-2007. The logarithms of OOPE on health of these individuals are then inestimable. To offset this issue, we categorize the OOPE on health in four classes. The first, second, third and forth classes are composed respectively of $OOPE \in ]0; Medium]$, $OOPE \in ]Medium; Q3]$, $OOPE \in ]Q3; D9]$ and $OOPE \in ]D9; Max]$. It implies that instead of explaining the variation of labor productivity by the variation of OOPE on health amount, we explain the variation of individual productivity by the relative level of OOPE on health. The empirical results are outlined in Table 2.4.

Table 2.4: The effects of OOPE on health on labor productivity

| | Dependant variable: $Ln$ Wage Income $(t+1)$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | | | (2) | | |
| | Estimated Parameter | | Standard Error | Estimated Parameter | | Standard Error |
| $Ln$ Health Score (t) | 0,187 | * | (0,104) | | | |
| Excellent health (t) | | | | 0,194 | | (0,109) |
| Very good health (t) | | | | 0,262 | | (0,105) |
| Good health (t) | | | | 0,184 | | (0,103) |
| Fair health (t) | | | | 0,103 | | (0,107) |
| Poor health (t) | | | | REF | | REF |
| OOPE $\in ]0; Medium]$ | 0,064 | | (0,101) | 0,063 | | (0,100) |
| OOPE $\in ]Medium; Q3]$ | 0,099 | | (0,102) | 0,102 | | (0,101) |
| OOPE $\in ]Q3; D9]$ | 0,081 | | (0,104) | 0,085 | | (0,104) |
| OOPE $\in ]D9; Max]$ | 0,047 | | (0,059) | 0,047 | | (0,059) |
| $Ln$ Year of Education | 0,216 | *** | (0,032) | 0,208 | *** | (0,032) |
| Gender | -0,306 | *** | (0,030) | -0,312 | *** | (0,030) |
| Physically demanding job | -0,206 | *** | (0,030) | -0,205 | *** | (0,030) |
| $Ln$ Working Hours | 0,553 | *** | (0,030) | 0,549 | *** | (0,030) |
| Country fixed effects | YES | | | YES | | |
| N | 3360 | | | 3360 | | |
| $R^2$ | 0,403 | | | 0,406 | | |

Column (1) describes the results obtained by using a $Log - Log$ regression.
For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression.
For that purpose, we approximate the health status by the Self-Perceived-Health and we categorize the expenditures on health
*REF* indicates that poor health is baseline in the Self-Perceived-Health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

The results suggest that OOPE on health, made by elderly workers during 2006-

2007, have a limited and not significant effect on their productivity during 2010-2011 (see column 1 of Table 2.4). Namely, it seems that, *ceteris paribus*, the elderly workers are not able to improve their productivity by making more OOPE on health. Nonetheless, it appears that health status at the previous period affects positively and significantly the productivity at the contemporaneous period. This result is in line with theoretical insight assimilating health as a stock variable having lasting effect on labor productivity.

Note that these results are obtained by approximating the previous health status ($h^t_{i,t}$) by health score. Could these results still valid with another health indicator ? To answer this question, we perform the same estimation by substituting health score by Self-Perceived Health (referred to below as SPH). SPH is a subjective health indicator provided by SHARE. It is a polynomial variable taking 5 values ranged between 1 and 5[20]. A regression with the Logit method is then used to estimate equation (2.20) when we approximate $h^t_{i,t}$ by SPH. The results obtained in Column 2 of Table 2.4 suggest that our previous finding are still valid with this alternative health indicator. The effect of OOPE on health on labor productivity remains low and insignificant contrariwise to effect of previous health status on individual productivity.

To check the robustness of these results, we perform the same econometrics estimation only on female subsample and thereafter only on male subsample. Table 2.5 summarizes the results obtained by undertaking these separate econometric estimations and confirms the limited and insignificant effect of OOPE on health on labor productivity. We also execute another regression by defining OOPE on health as the sum of OOPE only on*inpatient care, outpatient care and prescribed drugs.* It implies that we do not take into account the OOPE *on nursing home, day-care and home-care* in this robustness test. We exclude these health expenditures because one can think that these spending are constrained by an existing illness and cannot be assimilated as a voluntary health investment. The results are outlined in Table 2.6 and also underline the low and insignificant effect of OOPE on health on labor productivity. The results obtained by defining the OOPE on health as the sum of OOPE on only *inpatient care,*

[20] $SPH = 1$ indicates a poor health and $SPH = 5$ designates an excellent health.

*outpatient care and prescribed drugs* and by undertaking two separate econometric estimations for female and male are summarized in Table 2.7. These results also confirm the outcomes of the previous regressions. It seems then that OOPE on health has a limited and insignificant effect on labor productivity of elderly workers and this result seems to be robust.

Table 2.5: The effects of OOPE on health on labor productivity by separating female and male

| | Dependant variable: *Ln* Wage Income $(t+1)$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | | | (2) | | | |
| | Female | | Male | | Female | | Male | |
| | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error |
| *Ln* Health Score (t) | 0,176 | (0,134) | 0,241 | (0,165) | | | | |
| Excellent health (t) | | | | | 0,172 | (0,151) | 0,256 * | (0,157) |
| Very good health (t) | | | | | 0,230 | (0,145) | 0,342 ** | (0,152) |
| Good health (t) | | | | | 0,184 | (0,142) | 0,229 | (0,150) |
| Fair health (t) | | | | | 0,096 | (0,148) | 0,145 | (0,155) |
| Poor health (t) | | | | | REF | REF | REF | REF |
| OOPE $\in ]0; Medium]$ | 0,010 | (0,135) | 0,105 | (0,150) | 0,011 | (0,135) | 0,106 | (0,150) |
| OOPE $\in ]Medium; Q3]$ | 0,066 | (0,136) | 0,125 | (0,153) | 0,069 | (0,136) | 0,131 | (0,153) |
| OOPE $\in ]Q3; D9]$ | 0,013 | (0,140) | 0,139 | (0,157) | 0,018 | (0,140) | 0,147 | (0,157) |
| OOPE $\in ]D9; Max]$ | 0,103 | (0,079) | -0,022 | (0,090) | 0,098 | (0,079) | -0,013 | (0,090) |
| *Ln* Year of Education | 0,255 *** | (0,044) | 0,165 *** | (0,047) | 0,249 *** | (0,044) | 0,156 *** | (0,047) |
| Physically demanding job | -0,194 *** | (0,042) | -0,198 *** | (0,043) | -0,194 *** | (0,042) | -0,195 *** | (0,043) |
| *Ln* Working Hours | 0,612 *** | (0,039) | 0,349 *** | (0,050) | 0,610 *** | (0,039) | 0,343 *** | (0,050) |
| Country fixed effects | YES | | YES | | YES | | YES | |
| N | 1804 | | 1556 | | 1804 | | 1556 | |
| $R^2$ | 0,376 | | 0,397 | | 0,377 | | 0,402 | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Table 2.6: The effects of OOPE on health on labor productivity by measuring the OOPE on health as the sum of OOPE on only inpatient care, outpatient care and prescribed drugs

| | Dependant variable: $Ln$ Wage Income $(t+1)$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | | | (2) | | |
| | Estimated Parameter | | Standard Error | Estimated Parameter | | Standard Error |
| $Ln$ Health Score (t) | 0,192 | *** | (0,046) | | | |
| Excellent health (t) | | | | 0,194 | *** | (0,049) |
| Very good health (t) | | | | 0,262 | *** | (0,047) |
| Good health (t) | | | | 0,183 | *** | (0,046) |
| Fair health (t) | | | | 0,102 | ** | (0,048) |
| Poor health (t) | | | | REF | | REF |
| OOPE $\in ]0; Medium]$ | -0,037 | | (0,045) | -0,034 | | (0,045) |
| OOPE $\in ]Medium; Q3]$ | -0,012 | | (0,046) | -0,005 | | (0,046) |
| OOPE $\in ]Q3; D9]$ | -0,017 | | (0,047) | -0,007 | | (0,047) |
| OOPE $\in ]D9; Max]$ | 0,045 | | (0,026) | 0,042 | | (0,026) |
| $Ln$ Year of Education | 0,216 | *** | (0,014) | 0,209 | *** | (0,014) |
| Gender | -0,308 | *** | (0,013) | -0,314 | *** | (0,013) |
| Physically demanding job | -0,207 | *** | (0,014) | -0,205 | *** | (0,013) |
| $Ln$ Working Hours | 0,552 | *** | (0,013) | 0,549 | *** | (0,013) |
| Country fixed effects | YES | | | YES | | |
| N | 16800 | | | 16800 | | |
| $R^2$ | 0,404 | | | 0,406 | | |

In this regression, we define the OOPE on health as the sum of the OOPE on only: inpatient care, outpatient care and prescribed drugs
Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Table 2.7: The effects of OOPE on health on labor productivity by measuring the OOPE on health as the sum of OOPE on only inpatient care, outpatient care and prescribed drugs, and by separating female and male

| | Dependant variable: $Ln$ Wage Income $(t+1)$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | | | (2) | | | |
| | Female | | Male | | Female | | Male | |
| | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error |
| $Ln$ Health Score (t) | 0,179 *** | (0,060) | 0,252 *** | (0,073) | | | | |
| Excellent health (t) | | | | | 0,170 ** | (0,067) | 0,256 *** | (0,070) |
| Very good health (t) | | | | | 0,230 *** | (0,064) | 0,343 *** | (0,067) |
| Good health (t) | | | | | 0,185 *** | (0,063) | 0,231 *** | (0,066) |
| Fair health (t) | | | | | 0,096 | (0,066) | 0,146 ** | (0,069) |
| Poor health (t) | | | | | REF | REF | REF | REF |
| OOPE $\in ]0; Medium]$ | -0,003 | (0,059) | -0,135 ** | (0,070) | 0,004 | (0,059) | -0,132 * | (0,070) |
| OOPE $\in ]Medium; Q3]$ | 0,052 | (0,059) | -0,140 ** | (0,072) | 0,062 | (0,059) | -0,132 | (0,071) |
| OOPE $\in ]Q3; D9]$ | 0,007 | (0,061) | -0,109 | (0,073) | 0,019 | (0,061) | -0,098 | (0,073) |
| OOPE $\in ]D9; Max]$ | 0,091 *** | (0,035) | 0,003 | (0,040) | 0,084 ** | (0,084) | 0,007 | (0,040) |
| $Ln$ Year of Education | 0,255 *** | (0,019) | 0,163 *** | (0,021) | 0,249 *** | (0,249) | 0,155 *** | (0,021) |
| Physically demanding job | -0,193 *** | (0,019) | -0,201 *** | (0,019) | -0,193 *** | -(0,193) | -0,198 *** | (0,019) |
| $Ln$ Working Hours | 0,612 *** | (0,017) | 0,345 *** | (0,022) | 0,610 *** | (0,610) | 0,339 *** | (0,022) |
| Country fixed effects | YES | | YES | | YES | | YES | |
| N | 9020 | | 7780 | | 9020 | | 7780 | |
| $R^2$ | 0,376 | | 0,397 | | 0,377 | | 0,401 | |

In this regression, we define the OOPE on health as the sum of the OOPE on only: inpatient care, outpatient care and prescribed drugs

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health

Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health

*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Note that, whatever the health indicator, we obtain the expected result about the effect of years of education, gender, job occupation and labor supply on labor productivity. Indeed, it seems that years of schooling improve significantly the individual productivity. This result is consistent with literature on the investment in human capital. In addition, like in Hellerstein, Neumark, and Troske (1999), we estimate that women produce significantly less than men. But, this result could also reflect more wage discrimination between gender than productivity differences. Unfortunately, isolate the pure effect of wage discrimination and productivity differences between gender is beyond the scope of this chapter. Our empirical results also highlight the negative and significant effect of physically demanding job on elderly labor productivity. Reducing the physical intensity of jobs held by elderly workers could then be one low-cost solution to improve their productivity.

## 2.3 The second empirical analysis

The results outlined in Section 2.2.3 underline a limited and insignificant correlation between OOPE on health and elderly workers productivity. However, this empirical evidence is based on the theoretical result suggesting a positive effect of the current labor in health form on the current labor productivity (see equation 2.18). In addition, this theoretical result is obtained by assuming a positive and concave relationship between the current labor in health form and the previous OOPE on health (see equation 2.7). In short, the empirical results outlined in Section 2.2.3 depend on the relevance of the relationship highlighted in equations (2.18) and (2.7). Could then the weak correlation between OOPE on health and labor productivity be explained by the irrelevance of the relationship (i) between the previous OOPE on health and the current labor in health form and (ii) between the current labor in health form and the current labor productivity ? To answer this question, we check the empirical relevance of equations (2.7) and (2.18) by approximating as previously the labor in health form by health status.

### 2.3.1 OOPE on health and health status

According to our theoretical model, the relationship between OOPE on health and health status follows equation (2.7). As discussed in Section 2.1.1, this equation implies that the current health status only depends on the previous health status ($h^t_{i,t}$) and the previous amount allocated to OOPE on health ($m^t_{i,t}$). However, other individual parameters also affect the individual health status. Unfortunately, we do not consider these parameters in Section 2.1.1 in order to have a tractable theoretical model. But not including these parameters in our empirical analysis could induce some omitted variables bias which could not allow to isolate accurately the real effect of OOPE on health on state of health. Thus, to offset the omitted variables bias, we include some other individual variables in equation (2.7) in the same line with economic and health literatures on individual determinants of health.

According to Avendano, Jurges, and Mackenbach (2009); Bijwaard, Kippersluis, and Veenman (2013); Bleakley, Lleras-muney, and Costa (2013); Fonseca and Zheng (2013), skills affects significantly health status. *Ceteris paribus*, it seems that more educated people have better health than less educated people. Like in Section 2.2.1.2, we then consider this parameter by approximating skills by the number of years of education (referred to below as $YOE$) and by including this latter in equation (2.7). The second individual parameter influencing health status is job occupation (Karasek, Theorell, Schwartz, Schnall, Pieper, and Michela 1988). *Ceteris paribus*, individual holding a less physically demanding job is healthier than one having a more physically demanding job. To take into account this parameter, we then insert the variable physically demanding job ($PDJ$) in equation (2.7) [21]. The third parameter affecting health is gender. Indeed, according to medical studies (Artazcoz, Borrell, and Benach (2001); McDonough and Walters (2001)), *ceteris paribus*, men are healthier than women. Introducing the variable *Gender* in equation (2.7) then allows to consider the effect of gender on health status[22]. The fourth parameter determining the individual health is

[21] As in section 2.2.1.2, $PDJ$ is a dummy variable such that $PDJ = 0$ indicates no physically demanding job and $PDJ = 1$ describes the opposite

[22] As in section 2.2.1.2, *Gender* is also a dummy variable such that $Gender = 0$ indicates a man and $Gender = 1$ describes a woman

purely physiological and refers to the proportionality between weight and height. This proportionality is given by the Body Mass Index (referred to below as $BMI$)[23]. However, the relationship between weight and height informed by $BMI$ follows an inverted U shape relationship. To capture this inverted U shape relationship, we also control for the square of $BMI$. The last parameters influencing the individual health are related to each individual way of life, namely smoking and drinking alcohol. To consider them, we include two additional dummy variables which are $Smoking$ and $DA$[24] in equation (2.7). $Smoking = 1$ and $DA = 1$ indicate the behavior of an individual who smokes and drinks alcohol.

By taking into account all these parameters, we deduce the empirical model allowing to assess the effect of the previous OOPE on health on the current state of health:

$$\begin{aligned} \ln h_{i,t+1} &= b + b_1 \ln h_{i,t} + b_2 \times ln\left(m_{i,t}^t\right) + b_3 \ln YOE + b_4 PDJ + b_5 Gender \\ &\quad + b_6 \ln BMI + b_7 \left(\ln BMI\right)^2 + b_8 Smoking + b_9 DA + \varepsilon_2 \end{aligned} \tag{2.21}$$

This empirical model is just the log-linearized expression of equation (2.7) augmented by $YOE$, $PDJ$, $Gender$, $BMI$, $Smoking$ and $DA$ variables. It implies that in equation (2.21), $b_2 = \phi$. Moreover, following the previous discussion, we expect that the signs of $b_1$, $b_2$ and $b_3$ are positive unlike to the signs of $b_4$, $b_5$, $b_8$ and $b_9$. As usual, the sign of $b_7$ is expected to be the opposite of the sign of $b_6$.

### 2.3.2 Health status and labor productivity

Equation (2.18) demonstrates the positive effect of health status on individual productivity in our theoretical model (see Section 2.1.3). Estimating this equation allows to check the empirical relevance of this theoretical result. For that purpose, we apply the same empirical strategy as in Section 2.2 on equation (2.18). It implies that la-

[23]Medical studies estimate that the good BMI lies between 18.5 and 25. Outside this range, the BMI indicates a weight problem which could affect significantly the health.

[24]$DA$ for Drinking Alcohol

bor productivity is approximated by labor income. Moreover, equation (2.18) is also augmented by *Gender* and *PDJ* variables to avoid any omitted variables bias (see discussion in Section 2.2.1.2). Thus, the empirical model allowing to assess the effect of the current health status on the current labor productivity is:

$$\ln W_{i,t+1} = c + c_1 \ln(l_{i,t+1}) + c_2 \ln(e_{i,t+1}) + c_3 \ln(h_{i,t+1}) + c_4 Sex + c_5 PDJ + \varepsilon_3 \quad (2.22)$$

This empirical model is just the log-linearized expression of equation (2.18) augmented by *Gender* and *PDJ* variables. It implies that in equation (2.22), $c = \ln[\gamma + \eta + \rho]$, $c_1 = \gamma$, $c_2 = \eta$ and $c_3 = \rho$. Moreover, based on discussion in Section 2.2, we expect that the signs of $c_1$, $c_2$ and $c_3$ are positive contrariwise to the signs of $c_4$ and $c_5$.

### 2.3.3 Results

#### OOPE on health and state of health

The results concerning the effects of the previous OOPE on health on the current health status are reported in Table 2.8. It appears that, whatever the health indicator, the effect of the previous OOPE on health on the current health status is positive and significant. However, it seems that there is a threshold beyond which OOPE on health has not a significant positive effect on health status. This threshold is at the median of OOPE on health. It follows that below this threshold, OOPE on health can be assimilated as an investment expenditure on health improving health status at the next period. At the opposite, beyond this threshold, OOPE on health could become an unnecessary health spending[25]. The other results exhibited in Table 2.8 are consistent with those outlined in Table 2.4. Indeed, it seems that the correlation between the current and the previous health status is positive and significant. This empirical evidence is in the same line with the theoretical insight considering health as

[25]Elderly workers have higher health spending than the median OOPE on health because they may associate health as a superior good (Hall and Jones 2007). Higher is health spending, better is individual well-being.

a stock variable. In short, these results bring the empirical relevances on the positive effect of OOPE on health on state of health as it is assumed in equation (2.7).

Table 2.8: The effects of the previous OOPE on health on the current health status

| | Dependant variable: | | | | | |
|---|---|---|---|---|---|---|
| | *Ln* Health Score $(t+1)$ | | | Self-Perceived Health $(t+1)$ | | |
| | (1) | | | (2) | | |
| | Estimated Parameter | | Standard Error | Estimated Parameter | | Standard Error |
| OOPE$\in ]0; Medium]$ | 0,029 | ** | (0,014) | 0,358 | | (0,221) |
| OOPE$\in ]Medium; Q3]$ | 0,020 | | (0,014) | 0,129 | | (0,222) |
| OOPE$\in ]Q3; D9]$ | 0,016 | | (0,015) | 0,242 | | (0,230) |
| OOPE$\in ]D9; Max]$ | -0,007 | | (0,008) | -0,068 | | (0,133) |
| *Ln* Health Score $(t)$ | 0,311 | *** | (0,010) | | | |
| Health Score $(t+1)$ | | | | 0,102 | *** | (0,004) |
| Health Score $(t)$ | | | | 0,017 | *** | (0,003) |
| Gender | -0,023 | *** | (0,004) | 0,232 | *** | (0,067) |
| $LnBMI$ | 0,640 | ** | (0,321) | | | |
| BMI | | | | -0,090 | *** | (0,031) |
| $(LnBMI)^2$ | -0,113 | ** | ** | | | |
| $BMI^2$ | | | | 0,001 | | (0,001) |
| Smoking | -0,002 | | (0,005) | -0,352 | *** | (0,076) |
| Drinking alcohol | -0,009 | ** | (0,005) | 0,251 | *** | (0,075) |
| *Ln* Years of Education | 0,012 | *** | (0,005) | | | |
| Years of Education | | | | -0,037 | | (0,066) |
| Physically demanding job | -0,013 | *** | (0,004) | -0,217 | *** | (0,066) |
| Intercept (Excellent) | | | | -10,980 | *** | (0,672) |
| Intercept (Very Good) | | | | -9,176 | *** | (0,668) |
| Intercept (Good) | | | | -6,552 | *** | (0,657) |
| Intercept (Fair) | | | | -3,652 | *** | (0,649) |
| Intercept (Poor) | | | | REF | | REF |
| Country fixed effects | YES | | | NO | | |
| N | 3533 | | | 3578 | | |
| $R^2$ | 0,314 | | | | | |
| (Likelehood ratio test) $\chi^2 =$ | | | | 1384,008 | *** | |
| (Score test) $\chi^2 =$ | | | | 1068,879 | *** | |
| (Wald test) $\chi^2 =$ | | | | 1123,644 | *** | |
| Somers' D | | | | 0,533 | | |
| Gamma | | | | 0,535 | | |
| Tau-a | | | | 0,377 | | |
| c | | | | 0,766 | | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Estimating the effect of the previous OOPE on health on the current health status only on female subsample by using Log-Log regression confirms these results (see Table 2.9). However, the effect of OOPE on health on health status is insignificant for male old workers if we execute Log-Log regression. This effect is insignificant for both female and male if we approximate their health status by their Self-Perceived Health.

Table 2.9: The effects of OOPE on health on health status by separating female and male

| | Dependant variable: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ln$ Health Score $(t+1)$ | | | | Self-Perceived Health $(t+1)$ | | | |
| | (1) | | | | (2) | | | |
| | Female | | Male | | Female | | Male | |
| | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error |
| OOPE$\in ]0; Medium]$ | 0,038 ** | (0,020) | 0,014 | (0,021) | 0,450 | (0,280) | 0,072 | (0,363) |
| OOPE$\in ]Medium; Q3]$ | 0,019 | (0,020) | 0,018 | (0,021) | 0,223 | (0,281) | -0,156 | (0,366) |
| OOPE$\in ]Q3; D9]$ | 0,012 | (0,020) | 0,023 | (0,021) | 0,407 | (0,292) | -0,151 | (0,379) |
| OOPE$\in ]D9; Max]$ | 0,000 | (0,012) | -0,017 | (0,012) | -0,122 | (0,172) | 0,079 | (0,212) |
| $Ln$ Health Score $(t)$ | 0,284 *** | (0,012) | 0,383 *** | (0,016) | | | | |
| Health Score $(t+1)$ | | | | | 0,096 *** | (0,005) | 0,115 *** | (0,007) |
| Health Score $(t)$ | | | | | 0,013 *** | (0,004) | 0,027 *** | (0,005) |
| $LnBMI$ | 0,852 * | (0,498) | 0,642 | (0,415) | | | | |
| BMI | | | | | -0,222 *** | (0,069) | -0,080 ** | (0,040) |
| $(LnBMI)^2$ | -0,149 ** | ** | -0,108 * | (0,062) | | | | |
| $BMI^2$ | | | | | 0,003 *** | (0,001) | 0,000 | (0,001) |
| Smoking | -0,002 | (0,007) | -0,002 | (0,006) | -0,407 *** | (0,106) | -0,299 *** | (0,111) |
| Drinking alcohol | -0,010 | (0,008) | -0,009 | (0,006) | 0,369 *** | (0,119) | 0,200 ** | (0,098) |
| $Ln$ Years of Education | 0,014 ** | (0,007) | 0,011 * | (0,006) | | | | |
| Years of Education | | | | | -0,037 | (0,087) | -0,059 | (0,101) |
| Physically demanding job | -0,009 | (0,000) | -0,019 *** | (0,006) | -0,147 * | (0,090) | -0,291 *** | (0,099) |
| Intercept (Excellent) | | | | | -8,315 *** | (1,133) | -12,645 *** | (1,033) |
| Intercept (Very Good) | | | | | -6,512 *** | (1,131) | -10,815 *** | (1,027) |
| Intercept (Good) | | | | | -3,812 *** | (1,122) | -8,237 *** | (1,009) |
| Intercept (Fair) | | | | | -1,070 | (1,116) | -5,082 *** | (0,990) |
| Intercept (Poor) | | | | | REF | REF | REF | REF |
| Country fixed effects | YES | | YES | | NO | | NO | |
| N | 1894 | | 1639 | | 1895 | | 1639 | |
| $R^2$ | 0,303 | | 0,321 | | | | | |
| (Likelehood ratio test) $\chi^2 =$ | | | | | 754,159 *** | | 663,137 *** | |
| (Score test) $\chi^2 =$ | | | | | 588,601 *** | | 495,287 *** | |
| (Wald test) $\chi^2 =$ | | | | | 619,067 *** | | 524,688 *** | |
| Somers' D | | | | | 0,535 | | 0,541 | |
| Gamma | | | | | 0,538 | | 0,543 | |
| Tau-a | | | | | 0,376 | | 0,385 | |
| c | | | | | 0,768 | | 0,770 | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

In Table 2.10, we execute other econometric estimations by including female and male in the same sample and by defining OOPE on health as the sum of OOPE on only *inpatient care, outpatient care and prescribed drugs*. It appears that approximating health status by health score provides similar results to those in Table 2.8. Note that with this new definition of OOPE on health, the threshold beyond which OOPE on health has no significant positive effect on health status is estimated at the ninth decile of OOPE on health. Moreover, despite of this new definition of OOPE on health, Polynomial Logit regression underlines limited and insignificant effect of the previous OOPE on health on the current health status.

In Table 2.11, we also adopt this new definition of OOPE on health but undertake a separate regression for female and male. The results outlined in Table 2.11 confirm the previous ones. Indeed, by assessing health status through health score, we estimate that, below the ninth decile, OOPE on health can be assimilated as an investment expenditure on health improving health status at the next period for female and male subsamples. It seems also that beyond this threshold, OOPE on health has negative and significant effect on health status at the next period. We find the same results by approximating health status by Self-Perceived Health for female but not for male. To summarize, it seems that estimations of the effect of OOPE on health on state of health are quite sensitive to definition of OOPE on health, health indicator retained to assess health status, and gender. However, theses results do not challenge deeply the empirical relevances of the positive effect of OOPE on health on state of health as it is assumed in equation (2.7).

Table 2.10: The effects of OOPE on health on health status by measuring OOPE on health as the sum of OOPE on only inpatient care, outpatient care and prescribed drugs

| | Dependant variable: | | | | | |
|---|---|---|---|---|---|---|
| | *Ln* Health Score $(t+1)$ | | | Self-Perceived Health $(t+1)$ | | |
| | (1) | | | (2) | | |
| | Estimated Parameter | | Standard Error | Estimated Parameter | | Standard Error |
| OOPE$\in]0; Medium]$ | 0,040 | *** | (0,006) | 0,073 | | (0,100) |
| OOPE$\in]Medium; Q3]$ | 0,034 | *** | (0,007) | -0,174 | | (0,100) |
| OOPE$\in]Q3; D9]$ | 0,031 | *** | (0,007) | -0,105 | | (0,104) |
| OOPE$\in]D9; Max]$ | -0,015 | *** | (0,004) | 0,057 | | (0,059) |
| *Ln* Health Score $(t)$ | 0,311 | *** | (0,004) | | | |
| Health Score $(t+1)$ | | | | 0,102 | *** | (0,002) |
| Health Score $(t)$ | | | | 0,017 | *** | (0,001) |
| Gender | -0,023 | *** | (0,002) | 0,230 | *** | (0,030) |
| $LnBMI$ | 0,660 | *** | (0,143) | | | |
| BMI | | | | -0,088 | *** | (0,014) |
| $(LnBMI)^2$ | -0,116 | *** | (0,022) | | | |
| $BMI^2$ | | | | 0,001 | *** | (0,000) |
| Smoking | -0,002 | | | -0,349 | *** | (0,034) |
| Drinking alcohol | -0,010 | *** | (0,002) | 0,252 | *** | (0,034) |
| *Ln* Years of Education | 0,012 | *** | (0,002) | | | |
| Years of Education | | | | -0,034 | | (0,029) |
| Physically demanding job | -0,013 | *** | (0,002) | -0,219 | *** | (0,030) |
| Intercept (Excellent) | | | | -10,740 | *** | (0,304) |
| Intercept (Very Good) | | | | -8,937 | *** | (0,302) |
| Intercept (Good) | | | | -6,311 | *** | (0,297) |
| Intercept (Fair) | | | | -3,415 | *** | (0,294) |
| Intercept (Poor) | | | | REF | | REF |
| Country fixed effects | YES | | | NO | | |
| N | 17665 | | | 17670 | | |
| $R^2$ | 0,315 | | | | | |
| (Likelehood ratio test) $\chi^2 =$ | | | | 6921,012 | *** | |
| (Score test) $\chi^2 =$ | | | | 5349,966 | *** | |
| (Wald test) $\chi^2 =$ | | | | 5618,364 | *** | |
| Somers' D | | | | 0,533 | | |
| Gamma | | | | 0,535 | | |
| Tau-a | | | | 0,377 | | |
| c | | | | 0,766 | | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Table 2.11: The effects of OOPE on health on health status by measuring OOPE on health as the sum of OOPE on only inpatient care, outpatient care and prescribed drugs and by separating female and male

| | Dependant variable: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $Ln$ Health Score $(t+1)$ | | | | Self-Perceived Health $(t+1)$ | | | |
| | (1) | | | | (2) | | | |
| | Female | | Male | | Female | | Male | |
| | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error |
| OOPE$\in$]0; $Medium$] | 0,057 *** | (0,009) | 0,013 | (0,010) | 0,518 *** | (0,120) | -0,212 | (0,162) |
| OOPE$\in$]$Medium$; $Q3$] | 0,014 *** | (0,009) | 0,020 ** | (0,010) | 0,327 *** | (0,121) | -0,019 | (0,163) |
| OOPE$\in$]$Q3$; $D9$] | 0,035 *** | (0,009) | 0,026 ** | (0,010) | 0,343 *** | (0,126) | -0,019 | (0,169) |
| OOPE$\in$]$D9$; $Max$] | -0,009 * | (0,005) | -0,026 *** | (0,005) | 0,045 | (0,073) | 0,128 | (0,090) |
| $Ln$ Health Score $(t)$ | 0,284 *** | (0,006) | 0,383 *** | (0,007) | | | | |
| Health Score $(t+1)$ | | | | | -0,003 | (0,002) | -0,001 | (0,002) |
| Health Score $(t)$ | | | | | -0,005 *** | (0,002) | -0,004 * | (0,002) |
| $LnBMI$ | 0,863 *** | (0,222) | 0,689 *** | (0,183) | | | | |
| BMI | | | | | -5,173 * | (3,041) | -3,551 | (3,154) |
| $(LnBMI)^2$ | -0,151 *** | (0,034) | -0,115 *** | (0,027) | | | | |
| $BMI^2$ | | | | | 0,777 * | (0,462) | 0,413 | (0,472) |
| Smoking | -0,002 | (0,003) | -0,002 | (0,003) | -0,022 | (0,045) | 0,057 | (0,048) |
| Drinking alcohol | -0,010 *** | (0,004) | -0,009 *** | (0,003) | 0,210 *** | (0,051) | 0,073 * | (0,042) |
| $Ln$ Years of Education | 0,014 *** | (0,003) | 0,011 *** | (0,003) | | | | |
| Years of Education | | | | | -0,053 | (0,038) | -0,284 *** | (0,044) |
| Physically demanding job | -0,009 *** | (0,003) | -0,019 *** | (0,003) | 0,035 | (0,039) | -0,070 * | (0,043) |
| Intercept (Excellent) | | | | | 7,303 | (4,998) | 6,884 | (5,276) |
| Intercept (Very Good) | | | | | 8,023 * | (4,998) | 7,485 | (5,276) |
| Intercept (Good) | | | | | 9,664 ** | (4,998) | 9,099 * | (5,277) |
| Intercept (Fair) | | | | | 9,769 ** | (4,998) | 9,197 * | (5,277) |
| Intercept (Poor) | | | | | REF | REF | REF | REF |
| Country fixed effects | YES | | YES | | NO | | NO | |
| N | 9470 | | 8195 | | 9475 | | 8195 | |
| $R^2$ | 0,304 | | 0,323 | | | | | |
| (Likelehood ratio test) $\chi^2 =$ | | | | | 76,449 *** | | 105,253 *** | |
| (Score test) $\chi^2 =$ | | | | | 77,621 *** | | 106,142 *** | |
| (Wald test) $\chi^2 =$ | | | | | 74,955 *** | | 103,580 *** | |
| Somers' D | | | | | 0,077 | | 0,099 | |
| Gamma | | | | | 0,079 | | 0,100 | |
| Tau-a | | | | | 0,056 | | 0,071 | |
| c | | | | | 0,539 | | 0,549 | |

Column (1) describes the results obtained by using a $Log-Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health

Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health

*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Note that the effect of gender on health status varies across health indicator. Log-log regression underlines that being a woman is associated with a poorest health than being a man. This result is consistent with the expected sign about the gender difference in health status. However, Polynomial Logit regression highlights the opposite result. This opposite result is due to the health indicator used in Logit regression. Indeed, in Polynomial Logit regression, we approximate health status by self-perceived health ($SPH$). As $SPH$ indicates the subjective health, our results suggest that subjectively, it seems that women feel in better health than men. McDonough and Walters (2001) find a similar result. We also observe that the effects on health status of drinking alcohol and skills vary across health indicator. We think that these results reflect mainly the bias of subjectivity obtained with $SPH$.

**State of health and labor productivity**

The results on the effect of current health status on current labor productivity are summarized in Table 2.12. It appears that current health status has a positive and significant effect on elderly workers productivity. Moreover, the sign of coefficient associated with each control variable is the same as in Table 2.4. Consequently, these results bring the empirical relevance of the theoretical result obtained in equation (2.18). In other words, it seems that labor productivity of elderly worker is driven significantly by its current health status.

Making separate regression for female and male affects the significance of the effect of current health status on current labor productivity. Indeed, by approximating health status by health score, we can see in Table 2.13 that current health status has no significant positive effect on labor productivity for both female and male. We find the same result for female when we approximate health status by $SPH$. However, the positive and significant effect of health status on labor productivity is still valid for male. Note that creating female and male subsamples increases the standard error of both health score and $SPH$ of each subsample. That is why our results on the effect of OOPE on health on the state of health change when we distinguish the regression on female and male subsamples.

Table 2.12: The effects of health status on labor productivity

| | Dependant variable: *Ln* Wage Income $(t+1)$ | | | | | |
|---|---|---|---|---|---|---|
| | (1) | | | (2) | | |
| | Estimated Parameter | | Standard Error | Estimated Parameter | | Standard Error |
| *Ln* Health Score (t+1) | 0,171 | * | (0,102) | | | |
| Excellent health (t+1) | | | | 0,180 | * | (0,109) |
| Very good health (t+1) | | | | 0,251 | ** | (0,104) |
| Good health (t+1) | | | | 0,174 | * | (0,103) |
| Fair health (t+1) | | | | 0,097 | | (0,107) |
| Poor health (t+1) | | | | REF | | (REF) |
| *Ln* Years of Education | 0,218 | *** | (0,032) | 0,211 | *** | (0,032) |
| Gender | -0,305 | *** | (0,030) | -0,310 | *** | (0,030) |
| Physically demanding job | -0,207 | *** | (0,030) | -0,205 | *** | (0,030) |
| *Ln* Working Hours | 0,552 | *** | (0,030) | 0,549 | *** | (0,030) |
| Country fixed effects | YES | | | YES | | |
| N | 3360 | | | 3360 | | |
| $R^2$ | 0,4033 | | | 0,4053 | | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

Table 2.13: The effects of health status on labor productivity by separating female and male

| | Dependant variable: *Ln* Wage Income $(t+1)$ | | | | Dependant variable: *Ln* Wage Income $(t+1)$ | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | | | | (2) | | | |
| | Female | | Male | | Female | | Male | |
| | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error | Estimated Parameter | Standard Error |
| *Ln* Health Score (t+1) | 0,152 | (0,132) | 0,239 | (0,163) | | | | |
| Excellent health (t+1) | | | | | 0,151 | (0,151) | 0,251 * | (0,156) |
| Very good health (t+1) | | | | | 0,216 | (0,144) | 0,339 ** | (0,151) |
| Good health (t+1) | | | | | 0,170 | (0,142) | 0,228 | (0,149) |
| Fair health (t+1) | | | | | 0,086 | (0,148) | 0,146 | (0,154) |
| Poor health (t+1) | | | | | REF | (REF) | REF | (REF) |
| *Ln* Years of Education | 0,258 *** | (0,043) | 0,164 *** | (0,047) | 0,252 *** | (0,043) | 0,1556 *** | (0,047) |
| Physically demanding job | -0,195 *** | (0,042) | -0,200 *** | (0,043) | -0,1948 *** | (0,042) | -0,1968 *** | (0,043) |
| *Ln* Working Hours | 0,613 *** | (0,039) | 0,347 *** | (0,050) | 0,6112 *** | (0,039) | 0,3416 *** | (0,050) |
| Country fixed effects | YES | | YES | | YES | | YES | |
| N | 1804 | | 1556 | | 1804 | | 1556 | |
| $R^2$ | 0,375 | | 0,397 | | 0,376 | | 0,401 | |

Column (1) describes the results obtained by using a $Log - Log$ regression. For that purpose, we approximate the health status by the Health Score and we categorize the expenditures on health
Column (2) describes the results by using a Polynomial Logit regression. For that purpose, we approximate the health status by the Self-Perceived Health and we categorize the expenditures on health
*** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level

## 2.4 Conclusion

This chapter provides a theoretical model and empirical evidences on the relationship between out-of-pocket expenditure on health and labor productivity of old workers. Theoretically, we demonstrate that old workers are able to enhance their labor productivity by spending more in heath during prime-age. We check the empirical relevance of this theoretical insight by exploiting SHARE database. However, our empirical results suggest that out-of-pocket expenditure on health has no significant positive effect on labor productivity of elderly workers. It seems then that increasing out-of-pocket expenditure on health, near the end of the active life, is not the best way to improve the productivity of old workers.

Nevertheless, our empirical results suggest that old workers could improve their productivity through three other channels. The first channel is the past state of health. Indeed, the past health status has a significant positive effect on productivity of old workers. This result supports (i) the theoretical insight considering health as a stock variable evolving over time (Grossman (1972) and Barro (2013b) to name a few) and (ii) the economic literature paying attention on health investment at the early stage in life (Case, Fertig, and Paxson (2005), Bleakley, Lleras-muney, and Costa (2013), Bloom, Fink, and Canning (2013), Winter-ebmer and Halmdienst (2013), etc). The second channel is education. Our results suggest that investment in education has a long term effect on workers' life cycle. This result follows all theoretical and empirical findings about the benefits of investing in human capital (van Kippersluis, O'Donnell, and van Doorslaer (2009), Cutler and Lleras-muney (2012)). The third channel through which old workers could enhance their productivity is supplying more manpower. However, one observes that employment rate of old workers in European countries is low. Creating incentives allowing to maintain old workers in employment could then motivate the elderly workers to devote more time to labor.

Our empirical results also underline that correlation between physically demanding job and productivity of old workers is negative. In other words, to avoid any decrease in productivity due to physically demanding job, hiring old workers on jobs requiring less physical effort seems to be a good option. The same negative correlation is estimated between gender and labor productivity of elderly workers. But as mentioned in Section 2.3.3, this negative correlation could mainly reflect a wage discrimination against women.

# Appendix of Chapter 2

## A. Appendix on agent's decision

The agent's problem is:

$$\begin{cases} \underset{c_{i,t}^t, d_{i,t}^t, c_{i,t+1}^t, d_{i,t+1}^t}{Max} \quad U_{i,t} = \ln c_{i,t}^t + \ln d_{i,t}^t + \beta \left( \ln c_{i,t+1}^t + \ln d_{i,t+1}^t \right) \\ \\ subject\ to \quad w_{i,t}^L l_{i,t}^t + w_{i,t}^H h_{i,t}^t + w_{i,t}^E e_{i,t}^t = c_{i,t}^t + m_{i,t}^t + s_{i,t}^t \\ (1 + r_{t+1}) s_{i,t}^t + w_{i,t+1}^L l_{i,t+1}^t + w_{i,t+1}^H h_{i,t+1}^t + w_{i,t+1}^E e_{i,t+1}^t = c_{i,t+1}^t \\ l_{i,t}^t + u_{i,t}^t + d_{i,t}^t = 1 \\ l_{i,t+1}^t + d_{i,t+1}^t = 1 \\ h_{i,t+1}^t = h_{i,t}^t \left( m_{i,t}^t \right)^{\phi} \\ e_{i,t+1}^t = \Omega \left( u_{i,t}^t \right)^{\theta} \end{cases}$$

The first order conditions of this agent's problem provides the following relationship:

$$\frac{\partial U_{i,t}}{\partial l_{i,t}^t} = 0 \Leftrightarrow \frac{w_{i,t}^L}{c_{i,t}^t} = \frac{1}{1 - l_{i,t}^t - u_{i,t}^t} \tag{2.23}$$

$$\frac{\partial U_{i,t}}{\partial u_{i,t}^t} = 0 \Leftrightarrow \frac{\beta w_{t+1}^E \Omega \theta \left( u_{i,t}^t \right)^{\theta - 1}}{c_{i,t+1}^t} = \frac{1}{1 - l_{i,t}^t - u_{i,t}^t} \tag{2.24}$$

$$\frac{\partial U_{i,t}}{\partial m_{i,t}^t} = 0 \Leftrightarrow \frac{\beta \phi h_{i,t}^t w_{i,t+1}^H \left( m_{i,t}^t \right)^{\phi - 1}}{c_{i,t+1}^t} = \frac{1}{c_{i,t}^t} \tag{2.25}$$

$$\frac{\partial U}{\partial s_{i,t}^t} = 0 \Leftrightarrow \frac{\beta\left(1 + r_{t+1}\right)}{c_{i,t+1}^t} = \frac{1}{c_{i,t}^t} \tag{2.26}$$

$$\frac{\partial U}{\partial l_{i,t+1}^t} = 0 \Leftrightarrow \frac{w_{i,t+1}^L}{c_{i,t+1}^t} = \frac{1}{1 - l_{i,t+1}^t} \tag{2.27}$$

Thereafter, these relationship are exploited to determine the optimal $l_{i,t}^t$, $u_{i,t}^t$, $m_{i,t}^t$, $s_{i,t}^t$, $l_{i,t+1}^t$ and consequently the optimal $c_{i,t}^t$, $d_{i,t}^t$, $c_{i,t+1}^t$ and $d_{i,t+1}^t$.

**The young agent optimal health spending**

Equation (2.25) allows to write:

$$\beta\phi h_{i,t}^t w_{i,t+1}^H \left(m_{i,t}^t\right)^{\phi-1} = \frac{c_{i,t+1}^t}{c_{i,t}^t}$$

and equation (2.26) provides the Euler's equation:

$$c_{i,t+1}^t = \beta\left(1 + r_{t+1}\right) c_{i,t}^t \tag{2.28}$$

By combining equation (2.28) with the first relationship, we obtain:

$$\beta\phi h_{i,t}^t w_{i,t+1}^H \left(m_{i,t}^t\right)^{\phi-1} = \frac{\beta\left(1 + r_{t+1}\right) c_{i,t}^t}{c_{i,t}^t}$$

By simplifying this latter, we deduce equation (2.9) providing the optimal amount allocated by young agent to OOPE on health, namely:

$$m_{i,t}^t = \left(\frac{\phi h_{i,t}^t w_{i,t+1}^H}{\left(1 + r_{t+1}\right)}\right)^{\frac{1}{1-\phi}}$$

By substituting $m_{i,t}^t$ by equation (2.9) in equation (2.7), we obtain equation (2.11) indicating the exact expression of labor in health form at the second period, namely:

$$h_{i,t+1}^t = \left(h_{i,t}^t\right)^{\frac{1}{1-\phi}} \left(\frac{\phi w_{i,t+1}^H}{\left(1 + r_{t+1}\right)}\right)^{\frac{\phi}{1-\phi}}$$

**The young agent optimal time allocated to education**

By exploiting equation (2.24), we obtain:

$$\beta w_{t+1}^{E}\Omega\theta\left(u_{i,t}^{t}\right)^{\theta-1}=\frac{c_{i,t+1}^{t}}{1-l_{i,t}^{t}-u_{i,t}^{t}}$$

Moreover, equation (2.23) allows to write:

$$\left(1-l_{i,t}^{t}-u_{i,t}^{t}\right)w_{i,t}^{L}=c_{i,t}^{t}$$

By combining these two previous equations with equation (2.28), we deduce:

$$\beta w_{t+1}^{E}\Omega\theta\left(u_{i,t}^{t}\right)^{\theta-1}=\frac{\beta\left(1+r_{t+1}\right)\left(1-l_{i,t}^{t}-u_{i,t}^{t}\right)w_{i,t}^{L}}{\left(1-l_{i,t}^{t}-u_{i,t}^{t}\right)}$$

After simplification, we have:

$$u_{i,t}^{t}=\left(\frac{\Omega\theta w_{t+1}^{E}}{\left(1+r_{t+1}\right)w_{i,t}^{L}}\right)^{\frac{1}{1-\theta}}$$

This equation provides the optimal time devoted by young agent to education indicated in equation (2.8) in Section 2.1.1. It follows that by introducing equation (2.8) in equation (2.6), we deduce the exact expression of labor in knowledge form at the second period indicated in equation (2.10), namely

$$e_{i,t+1}^{t}=\Omega\left(\frac{\Omega\theta w_{t+1}^{E}}{\left(1+r_{t+1}\right)w_{i,t}^{L}}\right)^{\frac{\theta}{1-\theta}}$$

**The young agent optimal time allocated to work**

The combination of equation (2.5) and equation (2.28) gives:

$$\beta\left(1+r_{t+1}\right)c_{i,t}^{t}=\left(1+r_{t+1}\right)s_{i,t}^{t}+w_{i,t+1}^{L}l_{i,t+1}^{t}+w_{i,t+1}^{H}h_{i,t+1}^{t}+w_{i,t+1}^{E}e_{i,t+1}^{t}$$

It follows that:

$$c_{i,t}^{t}=\frac{s_{i,t}^{t}}{\beta}+\frac{w_{i,t+1}^{L}l_{i,t+1}^{t}}{\beta\left(1+r_{t+1}\right)}+\frac{w_{i,t+1}^{H}h_{i,t+1}^{t}}{\beta\left(1+r_{t+1}\right)}+\frac{w_{i,t+1}^{E}e_{i,t+1}^{t}}{\beta\left(1+r_{t+1}\right)}$$

Moreover, by exploiting the relationship provided by equation (2.27), we obtain:

$$\left(1 - l_{i,t+1}^{t}\right) w_{i,t+1}^{L} = c_{i,t+1}^{t}$$

By including the previous relationship in equation (2.5), we find:

$$\left(1 + r_{t+1}\right) s_{i,t}^{t} + w_{i,t+1}^{L} l_{i,t+1}^{t} + w_{i,t+1}^{H} h_{i,t+1}^{t} + w_{i,t+1}^{E} e_{i,t+1}^{t} = w_{i,t+1}^{L} - w_{i,t+1}^{L} l_{i,t+1}^{t}$$

It follows that after simplifying this result, we deduce the equation characterizing the optimal labor supply at the second period, namely:

$$l_{i,t+1}^{t} = \frac{1}{2} - \frac{w_{i,t+1}^{H}}{2w_{i,t+1}^{L}} h_{i,t+1}^{t} - \frac{w_{i,t+1}^{E}}{2w_{i,t+1}^{L}} e_{i,t+1}^{t} - \frac{\left(1 + r_{t+1}\right)}{2w_{i,t+1}^{L}} s_{i,t}^{t}$$

By inserting this previous relationship in expression indicating $c_{i,t}^{t}$, we have:

$$\begin{aligned} c_{i,t}^{t} = {} & \frac{s_{i,t}^{t}}{\beta} + \frac{w_{i,t+1}^{L}}{\beta\left(1 + r_{t+1}\right)} \left( \frac{1}{2} - \frac{w_{i,t+1}^{H}}{2w_{i,t+1}^{L}} h_{i,t+1}^{t} - \frac{w_{i,t+1}^{E}}{2w_{i,t+1}^{L}} e_{i,t+1}^{t} - \frac{\left(1 + r_{t+1}\right)}{2w_{i,t+1}^{L}} s_{i,t}^{t} \right) \\ & + \frac{w_{i,t+1}^{H} h_{i,t+1}^{t}}{\beta\left(1 + r_{t+1}\right)} + \frac{w_{i,t+1}^{E} e_{i,t+1}^{t}}{\beta\left(1 + r_{t+1}\right)} \end{aligned}$$

After some simplification, we obtain the exact expression of optimal consumption of young agent:

$$c_{i,t}^{t} = \frac{s_{i,t}^{t}}{2\beta} + \frac{w_{i,t+1}^{L}}{2\beta\left(1 + r_{t+1}\right)} + \frac{w_{i,t+1}^{H} h_{i,t+1}^{t}}{2\beta\left(1 + r_{t+1}\right)} + \frac{w_{i,t+1}^{E} e_{i,t+1}^{t}}{2\beta\left(1 + r_{t+1}\right)}$$

However, according to equation (2.23)

$$\left(1 - l_{i,t}^{t} - u_{i,t}^{t}\right) w_{i,t}^{L} = c_{i,t}^{t}$$

Thus, by introducing this relationship in equation characterizing $c_{i,t}^{t}$ and by substituting

$u^t_{i,t}$ by equation (2.8), we obtain:

$$w^L_{i,t} - w^L_{i,t} l^t_{i,t} - w^L_{i,t} \left( \frac{\Omega \theta w^E_{t+1}}{(1+r_{t+1})\, w^L_{i,t}} \right)^{\frac{1}{1-\theta}} = \frac{s^t_{i,t}}{2\beta} + \frac{w^L_{i,t+1}}{2\beta\,(1+r_{t+1})} + \frac{w^H_{i,t+1} h^t_{i,t+1}}{2\beta\,(1+r_{t+1})} + \frac{w^E_{i,t+1} e^t_{i,t+1}}{2\beta\,(1+r_{t+1})}$$

After simplification, we deduce equation describing the optimal saving

$$s^t_{i,t} = 2\beta w^L_{i,t} - 2\beta w^L_{i,t} l^t_{i,t} - 2\beta w^L_{i,t} \left( \frac{\Omega \theta w^E_{t+1}}{(1+r_{t+1})\, w^L_{i,t}} \right)^{\frac{1}{1-\theta}} - \frac{w^L_{i,t+1}}{(1+r_{t+1})} - \frac{w^H_{i,t+1} h^t_{i,t+1}}{(1+r_{t+1})} - \frac{w^E_{i,t+1} e^t_{i,t+1}}{(1+r_{t+1})}$$

In addition, according to equation (2.4)

$$w^L_{i,t} l^t_{i,t} + w^H_{i,t} h^t_{i,t} + w^E_{i,t} e^t_{i,t} = c^t_{i,t} + m^t_{i,t} + s^t_{i,t}$$

It follows that by combining equation (2.23) with equation (2.8), the previous relationship becomes:

$$c^t_{i,t} = w^L_{i,t} - w^L_{i,t} l^t_{i,t} - w^L_{i,t} \left( \frac{\Omega \theta w^E_{t+1}}{(1+r_{t+1})\, w^L_{i,t}} \right)^{\frac{1}{1-\theta}}$$

And according to our previous calculation:

$$s^t_{i,t} = 2\beta w^L_{i,t} - 2\beta w^L_{i,t} l^t_{i,t} - 2\beta w^L_{i,t} \left( \frac{\Omega \theta w^E_{t+1}}{(1+r_{t+1})\, w^L_{i,t}} \right)^{\frac{1}{1-\theta}} - \frac{w^L_{i,t+1}}{(1+r_{t+1})} - \frac{w^H_{i,t+1} h^t_{i,t+1}}{(1+r_{t+1})} - \frac{w^E_{i,t+1} e^t_{i,t+1}}{(1+r_{t+1})}$$

and

$$m^t_{i,t} = \left( \frac{\phi h^t_{i,t} w^H_{i,t+1}}{(1+r_{t+1})} \right)^{\frac{1}{1-\phi}}$$

It implies that by substituting $c^t_{i,t}$, $s^t_{i,t}$ and $m^t_{i,t}$ in equation (2.4) by the three previous equations characterizing the exact expression of $c^t_{i,t}$, $s^t_{i,t}$ and $m^t_{i,t}$, equation (2.4) becomes

$$\begin{aligned} w_{i,t}^{L} l_{i,t}^{t} + 2\beta w_{i,t}^{L} l_{i,t}^{t} + w_{i,t}^{L} l_{i,t}^{t} = w_{i,t}^{L} - w_{i,t}^{L} \left( \frac{\Omega \theta w_{t+1}^{E}}{(1+r_{t+1})\, w_{i,t}^{L}} \right)^{\frac{1}{1-\theta}} + \left( \frac{\phi h_{i,t}^{t} w_{i,t+1}^{H}}{(1+r_{t+1})} \right)^{\frac{1}{1-\phi}} \\ - w_{i,t}^{H} h_{i,t}^{t} - w_{i,t}^{E} e_{i,t}^{t} + 2\beta w_{i,t}^{L} - 2\beta w_{i,t}^{L} \left( \frac{\Omega \theta w_{t+1}^{E}}{(1+r_{t+1})\, w_{i,t}^{L}} \right)^{\frac{1}{1-\theta}} \\ - \frac{w_{i,t+1}^{L}}{(1+r_{t+1})} - \frac{w_{i,t+1}^{H} h_{i,t+1}^{t}}{(1+r_{t+1})} - \frac{w_{i,t+1}^{E} e_{i,t+1}^{t}}{(1+r_{t+1})} \end{aligned}$$

Thus, after some simplification and by substituting $h_{i,t+1}^{t}$ and $e_{i,t+1}^{t}$ by respectively equations (2.11) and (2.10), we obtain the exact expression of time allocated by young agent to work:

$$\begin{aligned} l_{i,t}^{t} = \frac{(1+2\beta)}{(2+2\beta)} - \frac{w_{i,t}^{H} h_{i,t}^{t}}{(2+2\beta)\, w_{i,t}^{L}} - \frac{w_{i,t}^{E} e_{i,t}^{t}}{(2+2\beta)\, w_{i,t}^{L}} - \frac{w_{i,t+1}^{L}}{(2+2\beta)\, w_{i,t}^{L}\, (1+r_{t+1})} \\ + \frac{\left( \phi^{\frac{1}{1-\phi}} - \phi^{\frac{\phi}{1-\phi}} \right) \left( h_{i,t}^{t} w_{i,t+1}^{H} \right)^{\frac{1}{1-\phi}}}{(2+2\beta)\, w_{i,t}^{L}\, (1+r_{t+1})^{\frac{1}{1-\phi}}} - \frac{\left( (2\beta+1)\, \theta^{\frac{1}{1-\theta}} + \theta^{\frac{\theta}{1-\theta}} \right) \left( w_{i,t+1}^{E} \Omega \right)^{\frac{1}{1-\theta}}}{(2+2\beta) \left( (1+r_{t+1})\, w_{i,t}^{L} \right)^{\frac{1}{1-\theta}}} \end{aligned} \tag{2.29}$$

### The young agent optimal saving

Previously, we found that:

$$\begin{aligned} s_{i,t}^{t} = 2\beta w_{i,t}^{L} - 2\beta w_{i,t}^{L} l_{i,t}^{t} - 2\beta w_{i,t}^{L} \left( \frac{\Omega \theta w_{t+1}^{E}}{(1+r_{t+1})\, w_{i,t}^{L}} \right)^{\frac{1}{1-\theta}} \\ - \frac{w_{i,t+1}^{L}}{(1+r_{t+1})} - \frac{w_{i,t+1}^{H} h_{i,t+1}^{t}}{(1+r_{t+1})} - \frac{w_{i,t+1}^{E} e_{i,t+1}^{t}}{(1+r_{t+1})} \end{aligned}$$

Thus, by introducing equation (2.29) in $s_{i,t}^{t}$, by substituting $h_{i,t+1}^{t}$ and $e_{i,t+1}^{t}$ by respectively equations (2.11) and (2.10) and by simplifying our result, we obtain:

$$s_{i,t}^t = \frac{\beta}{(1+\beta)} w_{i,t}^L - \frac{w_{i,t+1}^L}{(1+\beta)(1+r_{t+1})} + \frac{w_{i,t}^H h_{i,t}^t \beta}{(1+\beta)} + \frac{\beta w_{i,t}^E e_{i,t}^t}{(1+\beta)} - \left( \frac{\phi^{\frac{\phi}{1-\phi}}}{\beta} + \phi^{\frac{1}{1-\phi}} \right) \frac{\beta \left( h_{i,t}^t w_{i,t+1}^H \right)^{\frac{1}{1-\phi}}}{(1+\beta)(1+r_{t+1})^{\frac{1}{1-\phi}}} - \left( \theta^{\frac{1}{1-\theta}} + \frac{1}{\beta} \theta^{\frac{\theta}{1-\theta}} \right) \frac{\beta w_{i,t}^L \left( \Omega w_{t+1}^E \right)^{\frac{1}{1-\theta}}}{(1+\beta)\left( (1+r_{t+1}) w_{i,t}^L \right)^{\frac{1}{1-\theta}}} \tag{2.30}$$

#### The young agent optimal consumption

The combination of relationship provided by equation (2.23) and equation (2.8) gives:

$$c_{i,t}^t = w_{i,t}^L - w_{i,t}^L l_{i,t}^t - w_{i,t}^L \left( \frac{\Omega \theta w_{t+1}^E}{(1+r_{t+1}) w_{i,t}^L} \right)^{\frac{1}{1-\theta}}$$

Thus, by introducing equation (2.29) in $c_{i,t}^t$ and by simplifying the result, we deduce that:

$$c_{i,t}^t = \frac{w_{i,t}^L}{(2+2\beta)} + \frac{w_{i,t+1}^L}{(2+2\beta)(1+r_{t+1})} + \frac{h_{i,t}^t w_{i,t}^L}{(2+2\beta)} + \frac{w_{i,t}^E e_{i,t}^t}{(2+2\beta)} + \frac{\left( \theta^{\frac{\theta}{1-\theta}} - \theta^{\frac{1}{1-\theta}} \right) w_{i,t}^L \left( \Omega w_{t+1}^E \right)^{\frac{1}{1-\theta}}}{(2+2\beta)\left( (1+r_{t+1}) w_{i,t}^L \right)^{\frac{1}{1-\theta}}} - \frac{\left( \phi^{\frac{1}{1-\phi}} - \phi^{\frac{\phi}{1-\phi}} \right) \left( h_{i,t}^t w_{i,t+1}^H \right)^{\frac{1}{1-\phi}}}{(2+2\beta)(1+r_{t+1})^{\frac{1}{1-\phi}}} \tag{2.31}$$

#### The old agent optimal time allocated to work

Previously, the combination of relationship provided by equation (2.27) and equation (2.5) allows to obtain:

$$l_{i,t+1}^t = \frac{1}{2} - \frac{w_{i,t+1}^H}{2 w_{i,t+1}^L} h_{i,t+1}^t - \frac{w_{i,t+1}^E}{2 w_{i,t+1}^L} e_{i,t+1}^t - \frac{(1+r_{t+1})}{2 w_{i,t+1}^L} s_{i,t}^t$$

Thus, by introducing equation (2.30) in the previous equation, by substituting $h_{i,t+1}^t$ and $e_{i,t+1}^t$ by respectively equations (2.11) and (2.10), and by simplifying the result, we obtain the exact expression of the old worker optimal time allocated to work

$$l_{i,t+1}^{t}=\frac{(2+\beta)}{2(1+\beta)}-\frac{\beta(1+r_{t+1})}{2(\beta+1)w_{i,t+1}^{L}}w_{i,t}^{L}-\frac{\beta(1+r_{t+1})w_{i,t}^{H}h_{i,t}^{t}}{2(\beta+1)w_{i,t+1}^{L}}-\frac{\beta(1+r_{t+1})w_{i,t}^{E}e_{i,t}^{t}}{2(\beta+1)w_{i,t+1}^{L}}$$
$$+\frac{\left(\phi^{\frac{1}{1-\phi}}-\phi^{\frac{\phi}{1-\phi}}\right)\beta\left(w_{i,t+1}^{H}h_{i,t}^{t}\right)^{\frac{1}{1-\phi}}}{2(1+\beta)w_{i,t+1}^{L}(1+r_{t+1})^{\frac{\phi}{1-\phi}}}+\left(\theta^{\frac{1}{1-\theta}}-\theta^{\frac{\theta}{1-\theta}}\right)\frac{\beta\left(\Omega w_{i,t+1}^{E}\right)^{\frac{1}{1-\theta}}}{2(1+\beta)w_{i,t+1}^{L}\left((1+r_{t+1})w_{i,t}^{L}\right)^{\frac{\theta}{1-\theta}}} \quad (2.32)$$

### The old worker optimal consumption

The relationship provided by equation (2.27) implies that:

$$c_{i,t+1}^{t}=w_{i,t+1}^{L}-w_{i,t+1}^{L}l_{i,t+1}^{t}$$

Thus, by plugging equation (2.32) in the previous relationship and by simplifying the result, we obtain

$$c_{i,t+1}^{t}=\frac{\beta}{(1+\beta)}w_{i,t+1}^{L}+\frac{\beta(1+r_{t+1})}{2(\beta+1)}w_{i,t}^{L}+\frac{\beta(1+r_{t+1})w_{i,t}^{H}h_{i,t}^{t}}{2(\beta+1)}+\frac{\beta(1+r_{t+1})w_{i,t}^{E}e_{i,t}^{t}}{2(\beta+1)}$$
$$-\left(\phi^{\frac{1}{1-\phi}}-\phi^{\frac{\phi}{1-\phi}}\right)\frac{\beta\left(w_{i,t+1}^{H}h_{i,t}^{t}\right)^{\frac{1}{1-\phi}}}{2(1+\beta)(1+r_{t+1})^{\frac{\phi}{1-\phi}}}-\left(\theta^{\frac{1}{1-\theta}}-\theta^{\frac{\theta}{1-\theta}}\right)\frac{\beta\left(\Omega w_{i,t+1}^{E}\right)^{\frac{1}{1-\theta}}}{2(1+\beta)\left((1+r_{t+1})w_{i,t}^{L}\right)^{\frac{\theta}{1-\theta}}} \quad (2.33)$$

## B. Appendix on firm's problem

Let $F(K_t,T_t,E_t,H_t)$ the neoclassical production function of the representative firm such that:

$$Y_t=F(K_t,T_t,E_t,H_t)=(K_t)^{\alpha}(T_t)^{\gamma}(E_t)^{\eta}(H_t)^{\rho} \quad (2.34)$$

with:

$$T_t = (L_{t-1} + L_t)\bar{l}_t \tag{2.35}$$

$$E_t = (L_{t-1} + L_t)\bar{e}_t \tag{2.36}$$

$$H_t = (L_{t-1} + L_t)\bar{h}_t \tag{2.37}$$

while by knowing that:

$$(L_{t-1} + L_t)\bar{l}_t = \int_I (L_{t-1} + L_t) l_{i,t} \mathrm{d}\mu(i) \tag{2.38}$$

$$(L_{t-1} + L_t)\bar{h}_t = \int_I (L_{t-1} + L_t) h_{i,t} \mathrm{d}\mu(i) \tag{2.39}$$

$$(L_{t-1} + L_t)\bar{e}_t = \int_I (L_{t-1} + L_t) e_{i,t} \mathrm{d}\mu(i) \tag{2.40}$$

The firm's problem is then:

$$Max \;\; \Pi = p_t \left(K_t\right)^{\alpha} \left(T_t\right)^{\gamma} \left(E_t\right)^{\eta} \left(H_t\right)^{\rho} - \left(r_t + \delta\right) K_t - w_t^L T_t - w_t^E E_t - w_t^H H_t$$

Thus, by assuming that $p_t = 1$, the first order conditions of this firm's problem are described by the following equations:

$$\frac{\partial \Pi}{\partial K_t} = 0 \Leftrightarrow r_t = \alpha \left(K_t\right)^{\alpha-1} \left(T_t\right)^{\gamma} \left(E_t\right)^{\eta} \left(H_t\right)^{\rho} - \delta \tag{2.41}$$

$$\frac{\partial \Pi}{\partial T_t} = 0 \Leftrightarrow w_t^L = \gamma \left(K_t\right)^{\alpha} \left(T_t\right)^{\gamma-1} \left(E_t\right)^{\eta} \left(H_t\right)^{\rho} \tag{2.42}$$

$$\frac{\partial \Pi}{\partial E_t} = 0 \Leftrightarrow w_t^E = \eta \left(K_t\right)^{\alpha} \left(T_t\right)^{\gamma} \left(E_t\right)^{\eta-1} \left(H_t\right)^{\rho} \tag{2.43}$$

$$\frac{\partial \Pi}{\partial H_t} = 0 \Leftrightarrow w_t^H = \rho \left(K_t\right)^{\alpha} \left(T_t\right)^{\gamma} \left(E_t\right)^{\eta} \left(H_t\right)^{\rho-1} \tag{2.44}$$

It implies that by assuming that $K_t = 1$ and $\gamma + \eta + \rho = 1$, equations (2.42), (2.43) and (2.44) become respectively:

$$w_t^L = \gamma\,(T_t)^{\gamma-1}\,(E_t)^{\eta}\,(H_t)^{\rho}$$

$$w_t^E = \eta\,(T_t)^{\gamma}\,(E_t)^{\eta-1}\,(H_t)^{\rho}$$

$$w_t^H = \rho\,(T_t)^{\gamma}\,(E_t)^{\eta}\,(H_t)^{\rho-1}$$

By inserting equations (2.35), (2.36) and (2.37) in $w_t^L$, $w_t^E$ and $w_t^H$ we obtain:

$$w_t^L = \gamma\left((L_{t-1}+L_t)\bar{l}_t\right)^{\gamma-1}((L_{t-1}+L_t)\bar{e}_t)^{\eta}\left((L_{t-1}+L_t)\bar{h}_t\right)^{\rho}$$

$$w_t^E = \eta\left((L_{t-1}+L_t)\bar{l}_t\right)^{\gamma}((L_{t-1}+L_t)\bar{e}_t)^{\eta-1}\left((L_{t-1}+L_t)\bar{h}_t\right)^{\rho}$$

$$w_t^H = \rho\left((L_{t-1}+L_t)\bar{l}_t\right)^{\gamma}((L_{t-1}+L_t)\bar{e}_t)^{\eta}\left((L_{t-1}+L_t)\bar{h}_t\right)^{\rho-1}$$

By substituting equations (2.35), (2.36) and (2.37) by respectively equations (2.38), (2.40) and (2.39), we deduce that:

$$w_t^L = \gamma\left(\int_I (N_{t-1}+N_t)l_{i,t}\mathrm{d}\mu(i)\right)^{\gamma-1}\left(\int_I (N_{t-1}+N_t)e_{i,t}\mathrm{d}\mu(i)\right)^{\eta}\left(\int_I (N_{t-1}+N_t)h_{i,t}\mathrm{d}\mu(i)\right)^{\rho}$$

$$w_t^E = \eta\left(\int_I (N_{t-1}+N_t)l_{i,t}\mathrm{d}\mu(i)\right)^{\gamma}\left(\int_I (N_{t-1}+N_t)e_{i,t}\mathrm{d}\mu(i)\right)^{\eta-1}\left(\int_I (N_{t-1}+N_t)h_{i,t}\mathrm{d}\mu(i)\right)^{\rho}$$

$$w_t^H = \rho\left(\int_I (N_{t-1}+N_t)l_{i,t}\mathrm{d}\mu(i)\right)^{\gamma}\left(\int_I (N_{t-1}+N_t)e_{i,t}\mathrm{d}\mu(i)\right)^{\eta}\left(\int_I (N_{t-1}+N_t)h_{i,t}\mathrm{d}\mu(i)\right)^{\rho-1}$$

Namely, due to the linearity of the integral, we have:

$$w_t^L = \gamma\left((N_{t-1}+N_t)l_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\gamma-1}\left((N_{t-1}+N_t)e_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\eta}\left((N_{t-1}+N_t)h_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\rho}$$

$$w_t^E = \eta\left((N_{t-1}+N_t)l_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\gamma}\left((N_{t-1}+N_t)e_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\eta-1}\left((N_{t-1}+N_t)h_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\rho}$$

$$w_t^H = \rho\left((N_{t-1}+N_t)l_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\gamma}\left((N_{t-1}+N_t)e_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\eta}\left((N_{t-1}+N_t)h_{i,t}\int_I \mathrm{d}\mu(i)\right)^{\rho-1}$$

However, as $\int_I \mathrm{d}\mu(i) = 1$ and as we assume that $\gamma + \eta + \rho = 1$, the previous equations become:

$$w_t^L = \gamma \left(l_{i,t}\right)^{\gamma-1} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

$$w_t^E = \eta \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta-1} \left(h_{i,t}\right)^{\rho}$$

$$w_t^H = \rho \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho-1}$$

We deduce then that expressions of $w_t^L l_{i,t}$, $w_t^E e_{i,t}$ and $w_t^H h_{i,t}$ as it is described in equations (2.13), (2.14) and (2.15), namely:

$$w_t^L l_{i,t} = \gamma \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

$$w_t^E e_{i,t} = \eta \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

$$w_t^H h_{i,t} = \rho \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

In addition, the total labor wage income of agent $i$ at time $t$ is given by $W_{i,t}$ such that:

$$W_{i,t} = w_t^L l_{i,t}^t + w_t^E e_{i,t}^t + w_t^H h_{i,t}^t$$

Thus, by inserting equations (2.13), (2.14) and (2.15) in $W_{i,t}$, we obtain

$$W_{i,t} = \gamma \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho} + \eta \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho} + \rho \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

After simplification, we conclude that:

$$W_{i,t} = (\gamma + \eta + \rho) \left(l_{i,t}\right)^{\gamma} \left(e_{i,t}\right)^{\eta} \left(h_{i,t}\right)^{\rho}$$

## C. The MCA method

Multiple Correspondence Analysis (MCA) is a multidimensional analysis method. Based on indicator matrix analysis (or complete disjunctive table), this method allows to synthesize categorical data by representing individuals - characterized by many variables

- as many points in a geometric space. A chi-square distance between the different categories of each variable is thereafter estimated. The closeness between each variable is expressed through this chi-square distance. An entire set of these distances composes then a map with several axis. The most important and the most representative axis of this map (in terms of variance accounted for) is the first one.

Table 2.14: Variables selected to build the Health Score

| Variables | Response Modalities |
|---|---|
| Long-term illness | Y/N |
| Pain in back, knees, hips or other joint | Selected/Not Selected |
| Heart trouble | Selected/Not Selected |
| Breathlessness | Selected/Not Selected |
| Persistent cough | Selected/Not Selected |
| Swollen legs | Selected/Not Selected |
| Sleeping problems | Selected/Not Selected |
| Falling down | Selected/Not Selected |
| Stomach or intestine problems | Selected/Not Selected |
| Fatigue | Selected/Not Selected |
| Eyesight distance | Excellent/Very good /Good/Fair/Poor |
| Eyesight reading | Excellent/Very good /Good/Fair/Poor |
| Use hearing aid | Y/N |
| Difficulties in walking 100 metres | Selected/Not Selected |
| Difficulties in sitting two hours | Selected/Not Selected |
| Difficulties in getting up from chair | Selected/Not Selected |
| Difficulties in stooping, kneeling, crouching | Selected/Not Selected |
| Difficulties in dressing, including shoes and socks | Selected/Not Selected |
| Irritability | Y/N |
| Ever told affective or emotional disorders | Y/N |

We exploit this methodology because questions related to health condition in SHARE database have in general answers with categorical modalities. MCA then allows to synthesize this large number of answers into an unique indicator. We define this indicator as the Health Score. For that purpose, we select 23 health indicators (see Table 2.14) and retain the first factorial axis which explains 39.92% of total variance (the second factorial axis explains 6.61% of variance, so there is a snap in the singular value histogram and neither of the following axis respects the Kaiser criteria). Thus, the Health Score generated by MCA is just the coordinate of each individual on this first axis. The worst health condition is related by the minimum coordinate and the maximum coordinate is associated with the best health condition. Note that each coordinate is ranged between 0 and 100.

# Part II

# The potential benefit effects of the future increase in both life expectancy and health spending on the French economy

After analyzing the effects of health spending intended to improve the quality of life and the effects of out-of-pocket expenditure on health on labor productivity, we quantify here the potential benefit effects from the future increase in both life expectancy and health spending.

As indicated in General Introduction, the main threat induced by population aging is the fiscal policy unsustainability. In Chapter 3, we verify if the potential benefit effects resulting from the future increase in life expectancy in France are able to offset the unsustainability of French fiscal policy. For that purpose, we develop a Generational Accounting Model (referred to below as GA). Auerbach, Gokhale, and Kotlikoff (1991) develop GA method to evaluate the fiscal policy that overcomes the inherent ambiguities of traditional deficit accounting. This method aims also to estimate the intergenerational fiscal burdens generated by a given fiscal policy. For that purpose, these authors suggest to compute for each generation the generational account which is, *in present value, what the typical member of each generation can expect to pay, now and in the future, in net taxes (taxes paid net of transfer payments received), but also what future generations must pay, given current policy and the government's intertemporal budget constraint.*

In sum, the generational account is just the present value of per capita net taxes that a generation will pay for the rest of its life under the assumed fiscal policy. To compare everyone on the same basis, GA calculates the effective rate at which each generation pays net taxes over its entire life, namely its lifetime net tax rate. It implies that a given fiscal policy is unsustainable if future generations must pay a different net tax rate than current newborns. At the opposite, the fiscal policy is sustainable if this latter affects equally each generation and can be followed forever without changing its expected effective rates on taxes, transfers, and spending.

For example, Auerbach, Gokhale, and Kotlikoff (1994) estimate that, to balance the intertemporal government's budget constraint in USA, future generations of males and females should have to pay respectively \$166,500 and \$83,400 during the rest of their life. These estimations indicate that these amount are 111.1% higher than fiscal burden faced by current newborns and illustrate the generational imbalanced of U.S. fiscal policy. Gokhale, Page, and Sturrock (1999) update these estimations and confirm the unsustainability of U.S. fiscal policy. They upgrade at \$9.4 trillion the fiscal burden bequeathed to future generations. However, Chojnicki and Docquier (2007) (referred to below as $CD$) estimate that Gokhale, Page, and Sturrock (1999) over-estimate the generational imbalance of U.S. fiscal policy. According to $CD$, all previous GA model applying the traditional methodology developed by Auerbach, Gokhale, and Kotlikoff (1991) do not consider the evolution of educational attainment of the successive cohorts which is an important source of heterogeneity within and between generations.

$CD$ argue that it is crucial to include skill heterogeneity in GA model as education is a key parameter for evaluating the long-run sustainability of a given fiscal policy. Indeed, the age profile of taxes and transfers are highly dependent on educational attainment and at the same time the skill structure of population changes significantly over time. Thus, by decomposing per schooling level the generational account of each generation estimated by Gokhale, Page, and Sturrock (1999), $CD$ compute that Gokhale, Page, and Sturrock (1999) overestimate the total burden bequeathed to future generations by about 30.7%.

In GA model, the positive impacts of the rise in educational attainment on fiscal policy occur implicitly through the well-known benefit effects of education on labor productivity (Mankiw, Romer, and Weil 1992). *Ceteris paribus*, higher educational level implies higher labor productivity, higher labor income and at least higher tax payment[26]. That is why the age profile of taxes is highly dependent on educational attainment. Thus, by disaggregating per schooling level the generational account of each generation, $CD$ manage to highlight the positive effects of one component of human capital, namely education, on labor productivity.

As indicated in General Introduction, health is another component of human capital impacting positively labor productivity. That is why one could expect that the future increase in life expectancy of French population, traducing an enhancement of French

[26]However, in general, as they have high tax payment, transfers perceived by high skills are higher than those perceived by low skill.

population health status, should generate in the same time an improvement in labor productivity. Thus, by developing a GA model applied to the French economy, we investigate in Chapter 3 if this future increase in life expectancy should be able to upgrade labor productivity like the rise in educational attainment.

However, the results provided by our Generational Accounting model do not consider all impacts of health improvement allowing this French population aging. In other words, we may under- or over-estimate the real impact of health improvement accompanying French population aging. The first reason explaining this misestimating is that population aging is not accompanied by health improvement only. As indicated in General Introduction, population aging is characterized by the decrease in size of active population (Blanchet 2001), the increase in capital/labor ratio (Blanchet 1988), the decline in level of aggregate saving (Krueger and Ludwig (2007), Ingenue (2005)) to name a few. The second reason explaining the misestimating of real economic effects of health improvement is that productivity gains are not the only returns to better health. As cited in General Introduction also, health improvement allows to extend population life time. Higher life expectancy can generate (i) more economic growth (Aisa and Pueyo 2004), more human capital accumulation (Blackburn and Cipriani 2002b) and less poverty (Chakraborty 2004). Welfare improvement is also an other benefit from an increase in life expectancy as underlined by Hall and Jones (2007).

To the best of our knowledge, none economic study proposes an unified framework analyzing the impacts of population aging resulting from better health, by considering the effect of health on productivity, mortality and well-being. General equilibrium models studying the economic effects of population aging neglect, most of the time, the effect of health on labor productivity (Auerbach and Kotlikoff (1987), Miles (1999), Aglietta, Chateau, Fayolle, Juillard, Le Caheux, Le Garrec, and Touzé (2007), Chojnicki and Magnani (2008), Mérette and Georges (2009), European Commission (2012), Sanchez-Romero, Sambt, and Prskawetz (2013)). In addition, General equilibrium models analyzing the economic impacts of better health (i) are not devoted to analyze specifically the population aging effects on economy (Aisa and Pueyo (2004), Bhattacharya and Qiao (2007), Blackburn and Cipriani (2002b) to name a few) and (ii) do not consider the simultaneous effect of better health on mortality, well-being and labor productivity (Gori and Sodini (2011), Pestieau and Ponthière (2012), Prettner and Canning (2012), Kai (2014) to name a few). That is why we attempt in Chapter 4 to develop a general equilibrium model allowing to study the effects of population aging by considering the impacts of health improvement on mortality, well-being and labor productivity. We exploit this general equilibrium framework to quantify also the potential benefit effects resulting from the future increase in health spending in France.

# Chapter 3

# The potential benefit effects of the future increase in life expectancy of French population on the government budget[1]

To assess the potential benefit effects from the future increase in French life expectancy of on fiscal policy, we revisit in Section 3.1 the traditional methodology of GA by introducing health and by considering education as suggested by Chojnicki and Docquier (2007) (CD). For that purpose, we describe in Section 3.1.1 the traditional framework of GA model in which tax and transfer aggregate amounts grow at the same pace with population and productivity growths. However, this classical methodology of GA assumes a constant productivity growth over time. Based on studies undertaken by Bloom and Canning (2005), Weil (2007), Aghion, Howitt, and Murtin (2011) and Barro (2013b), we then give up this strong assumption in Section 3.1.2 by assuming that productivity growth is driven partially by health improvement. To develop a GA model consistent with the one of $CD$, we also distinguish the health enhancement by skill

[1]This Chapter is based on a joint work with Xavier CHOJNICKI and refers to Chojnicki and Rabesandratana (2014)



level. Thereafter, this new methodology of GA is exploited to study the sustainability of French fiscal policy.

To the best of our knowledge, the last study on French fiscal policy sustainability was undertaken by Chojnicki (2013). By using a GA model with immigration, this author estimate that French fiscal policy is unsustainable in long term as the actual debt and future revenues and obligations of French government should be on the order of 200% of 2005's GDP. However, Chojnicki (2013) does not take into account the consequences of the rise in educational attainment of French population. GA study of Chojnicki (2013) may then overestimate the fiscal burden induced by French population aging as the skill structure of French population changes dramatically over time and is likely to evolve in future. We relate in Section 3.2.2 that share of population aged 80 in 2010 having a diploma level below *Baccalauréat* (referred to below as BAC)[2], between BAC and an university undergraduate degree, and higher qualification are respectively 72%, 13% and 15% (Blanpain and Chardon 2010). These proportion are equal to 35%, 24% and 41% for cohort aged 30. Thus, by assuming a stability in educational attainment of future young cohorts, the average educational level of French population should continue to grow due to the gradual rise of young and educated peoples in the age pyramid. We thus provide in this Chapter an assessment of the benefit effects resulting from the rise in educational attainment on French generational accounts.

Moreover, GA exercises undertaken by Chojnicki (2013) are highly sensitive to assumption on productivity growth. As it will be discussed in Section 3.2, there is no long term forecast on the evolution of each component of French government budget. Chojnicki (2013) accounts for the evolution of different components of public budget until 2007. Beyond 2007, he assumes that all individual taxes and transfers change at the same pace with productivity. However, like in traditional method of GA, the productivity is assumed to grow at a constant rate over time. This assumption involves that fiscal burden assessed by Chojnicki (2013) depends on the choice of productivity growth rate. Thus, by determining partially the productivity growth by health improvement, our GA method allows (i) to give up the traditional assumption on the

[2] *Baccalauréat* is the French equivalent to Higher Leaving Certificate.

productivity growth evolution, (ii) to obtain an evolution of each component of French public budget less sensitive to the choice of productivity growth rate and (iii) to account the potential productivity gains resulting from the future increase in life expectancy by measuring the fiscal gains generated by this latter.

The rest of this Chapter is organized as follows. Section 3.3.1 presents the results providing by the traditional methodology of GA developed by Auerbach, Gokhale, and Kotlikoff (1991). These results compose our baseline scenario. By adopting the traditional method, we evaluate the Intertemporal Public Liability (referred to below as IPL) induced by population aging at 2,260 billions (129% of GDP). Sections 3.3.2 and 3.3.4 expose the results obtained (i) by using the method developed by $CD$ and (ii) by applying our new methodology. Compared with the baseline results, we estimate by 63% the decrease in fiscal burden bequeathed to future generations allowed by the future change in skills structure of French population. We evaluate that productivity gains resulting from only health improvement of French population could reduce by 16% the baseline IPL. Finally, the simultaneous improvement in skill structure and health status of French population should generate productivity gains able to reduce by 79% the baseline IPL. The robustness of these results are discussed in Section 3.4. We conclude with Section 3.5.

## 3.1 A GA model with education and health

### 3.1.1 The usual framework

In the same spirit with Auerbach, Gokhale, and Kotlikoff (1991) and CD, we describe the intertemporal budget constraint of a given government as follow:

$$PVL_t + PVF_t = PVG_t - W_t \tag{3.1}$$

Equation (3.1) implies that the intertemporal government budget is balanced if the present value of government purchases ($PVG_t$), less the public net wealth ($W_t$), equalizes the sum of (i) the present value of net tax payments by living generations over the rest of their lives ($PVL_t$) and (ii) the present value of net tax payments by future born generations over the rest of their lives ($PVF_t$).

Like CD, we consider $W_t$ as the opposite of national debt, excluding the government's wealth, namely the government assets. In the same line with the classical methodology of GA, we obtain $PVG_t$, i.e. the present value of government purchases, by computing:

$$PVG_t = \sum_{s=t}^{\infty} \frac{G_s}{(1+i)^{s-t}} \tag{3.2}$$

in which $G_s$ assesses the non age-specific public consumption at year $s$ and $i$ indicates the discount rate. $PVG_t$ represents just the discounted sum of public expenditures. As usual, the evolution of $G_s$ follows the population growth and productivity growth because it is assumed that:

$$\frac{G_s}{p_s} = (1+\gamma)^{s-t} \frac{G_t}{p_t} \tag{3.3}$$

with $\gamma$ the productivity growth rate and $p_t$ the size of total population at year $t$.

$PVL_t$, i.e. the present value of net tax payments by living generations, is deduced by making the sum of generational accounts of living cohorts. It implies that by distinguishing three educational levels ($L$ = low skills, $M$ = medium skills and $H$ = high skills) in each generation like $CD$, we assess $PVL_t$ as follow:

$$PVL_t = \sum_{j=0}^{D} \left( n_{j,t}^{L} p_{j,t}^{L} + n_{j,t}^{M} p_{j,t}^{M} + n_{j,t}^{H} p_{j,t}^{H} \right) \tag{3.4}$$

with $p_{j,t}^{X}$ the size of population of type $X$ ($X = L, M, H$) with age $j$ at time $t$ and $n_{j,t}^{X}$ the generational account of the representative agent of this population. Note that, following the classical methodology, each individual in each generation lives maximum $D$ years.

The traditional definition of generational account (GA) provided by Auerbach, Gokhale, and Kotlikoff (1991) allows to consider the GA of living generations as the sum of present value of net taxes that these generations will pay over the rest of their lives. As, each generation is composed by population of type $X$ ($X = L, M, H$), the GA of population of type $X$ ($X = L, M, H$) with age $j$ at time $t$ is then given by:

$$n_{j,t}^{X} = \frac{1}{p_{j,t}^{X}} \sum_{k=j}^{D} \frac{\theta_{k,t+k-j}^{X} p_{k,t+k-j}^{X}}{(1+i)^{k-j}} \qquad j = 0, ..., D \qquad X = L, M, H \tag{3.5}$$

in which $\theta_{k,t+k-j}^{X}$ indicates the net tax payment by a representative agent of population of type $X$, aged $k$ at time $t+k-j$ and $p_{k,t+k-j}^{X}$ provides the size of this population. By assuming that government perceives (resp. allocates) $q$ types of taxes (resp. transfers) such that $q = 1, ..., Q$ and by considering that $\tau$ is a tax if $\tau > 0$ and $\tau$ is a transfer if $\tau < 0$, we measure $\theta_{k,t+k-j}^{X}$ as:

$$\theta_{k,t+k-j}^{X} = \sum_{q=1}^{Q} \tau_{k,t+k-j}^{X,q} \qquad X = L, M, H \tag{3.6}$$

with $\tau_{k,t+k-j}^{X,q}$ the tax (resp. transfer) profile of a representative agent of cohort $k$, with skill $X$ at time $t+k-j$ for the tax (resp. transfer) $q$.

### 3.1.2 The productivity growth rate

On one side, the classical methodology of GA considers a constant age distribution of taxes and transfers over time. On the other side, the tax and transfer profiles of the representative agent evolve at the same pace with labor productivity. In other words, it is assumed that:

$$\tau_{k,t+k-j+1}^{X,q} = (1+\gamma) \times \tau_{k,t+k-j}^{X,q} \qquad X = L, M, H \tag{3.7}$$

This relationship illustrates the significance of productivity growth in GA model. Indeed, even if the productivity growth $\gamma$ does not affect explicitly the age distribution of taxes and transfers, $\gamma$ determines the evolution of tax and transfer profiles over time. Higher is $\gamma$, higher is the tax (resp. transfer) payed (resp. allocated to) by the representative agent of each cohort over time.

Both Auerbach, Gokhale, and Kotlikoff (1991) and CD assume that $\gamma$ remains constant over time, even if empirically the productivity growth evolves over time. Moreover, the economic literature identifies explicitly the factors determining the productivity growth. These factors are mainly technological progress (Solow 1957) and human capital (Mankiw, Romer, and Weil 1992). However, the classical methodology of GA does not include explicitly the effects of these factors on the evolution of $\gamma$. It does not mean that classical methodology does not take into account the impacts of technical progress and human capital on labor productivity through $\gamma$. It just means that traditional method of GA considers $\gamma$ like an average productivity growth rate including productivity gains resulting from technological and human capital improvement. This average productivity growth rate is thereafter assumed to remain constant over time.

By disaggregating per schooling level the generational account of each cohort, the framework developed by $CD$ takes into account the effects of one component of human capital, namely education, on labor productivity. That is why we retain this methodology to undertake our GA exercises. However, over components influence human capital. As indicated in General Introduction, one of these components is health. Based on studies undertaken by Nelson and Phelps (1966) and Grossman (1972), Bloom and Canning (2005), Weil (2007), Aghion, Howitt, and Murtin (2011) and Barro (2013b), we include health in our GA model.

We assume that, at period $t+k-j$, workers with skill $X$ produce $Y^X_{t+k-j}$. For analytical convenience, we suppose that the technology to produce $Y^X_{t+k-j}$ is described by $F(A_{t+k-j}, H^X_{t+k-j})$ such that:

$$F\left(A_{t+k-j}, H^X_{t+k-j}\right) = A_{t+k-j}\left(H^X_{t+k-j}\right)^{\rho} \tag{3.8}$$

in which $H^X_{t+k-j}$ designates the health of workers with skill $X$ at period $t+k-j$ and $\rho$ the rate of returns of this latter. Following the class of neoclassical production function, $A_{t+k-j}$ indicates the total factor productivity (refereed to below as $TFP$) in economy at time $t+k-j$. Let $\gamma^X_{t+k-j}$, $g^A_{t+k-j}$ and $g^{h,X}_{t+k-j}$ the growth rates of respectively $Y^X_{t+k-j}$, $A_{t+k-j}$ and $H^X_{t+k-j}$. It involves that by applying the Solow Growth Decomposition

(Solow 1957) on equation (3.8), we obtain:

$$\gamma^{X}_{t+k-j} = g^{A}_{t+k-j} + \left(\rho \times g^{h,X}_{t+k-j}\right) \tag{3.9}$$

Equation (3.9) decomposes and isolates the main factors determining the productivity growth rate ($\gamma^{X}_{t+k-j}$) over time. It appears that one of these factors is $g^{h,X}_{t+k-j}$ that indicates the health improvement of workers with skill $X$ at period $t+k-j$. Equation (3.9) highlights then the explicit link between productivity growth and health improvement. This explicit link is thereafter introduced in our GA model to consider the benefit effect from health improvement on labor productivity. For that purpose, we substitute the traditional $\gamma$ used in the classical methodology of GA by $\gamma^{X}_{t+k-j}$. It implies that evolutions of tax and transfer profiles over time follow:

$$\tau^{X,q}_{k,t+k-j+1} = (1 + \gamma^{X}_{t+k-j}) \times \tau^{X,q}_{k,t+k-j} \qquad X = L, M, H \tag{3.10}$$

with $\gamma^{X}_{t+k-j}$ given by equation (3.9).

Basically, the substitution of $\gamma$ by $\gamma^{X}_{t+k-j}$ does not challenge significantly the classical methodology of GA. Indeed, do not consider the effect of health improvement on labor productivity in classical method just implies that $g^{h,X}_{t+k-j} = 0$ in equation (3.9) and then $\gamma^{X}_{t+k-j} = g^{A}_{t+k-j}$. The aim of substituting $\gamma$ by $\gamma^{X}_{t+k-j}$ is mainly to enhance the accuracy of labor productivity evolution because this latter determines the evolution of tax and transfer profiles over time. By improving the accuracy of the evolution of $\gamma$, we ameliorate at the same time the estimation of generational account of each cohort. Moreover, by revisiting the framework developed by $CD$, the evolution of $\gamma^{X}_{t+k-j}$ is determined by an explicit factor that is health improvement. As health improvement is not constant over time, $\gamma^{X}_{t+k-j}$ does not remain also constant over time like in the classical methodology.

To be consistent with the framework developed by CD, we distinguish by skill level the health enhancement in our GA exercise. It implies that productivity growth resulting from health improvement differs and is not shared equally across skills. Thus, by assuming that productivity growth follows equation (3.9), (i) we give up the traditional assumption on the constant evolution of $\gamma$, (ii) we consider health improvement as an explicit factor determining the evolution of $\gamma$ and (iii) we are able to capture the productivity gains induced by health enhancement.

### 3.1.3 Methodological limitations

Assuming that the evolution of productivity growth follows equation (3.9) implies that (i) $\rho$ is the same for each skill level and (ii) the productivity gains resulting from health improvement do not affect the age distribution of taxes and transfers across skills. In other words, we suppose implicitly that (i) the educational attainment has not any impact on $\rho$ and (ii) the health enhancement has not any effect on educational attainment driving the age distribution of taxes and transfers across skills.

One might think that (i) the value of $\rho$ depends positively on skill level and (ii) the health improvement has benefit effects on educational attainment and conversely. However, equation (3.9) neglects this interdependency between health improvement and educational attainment. GA model is not able to provide a suitable framework able to consider the interdependence between health improvement and educational attainment. GA model is an accounting model belonging to the class of partial equilibrium model. Its framework has not the appropriate feature to take into account any interdependency between health and skill.

In addition, including interdependence between health and skill involves that health improvement is able to change the age distribution of taxes and transfers across skills over time. Considering this interdependence could then (i) challenge deeply the GA methodology assuming that distribution of taxes and transfers across skills remains constant over time and (ii) require to develop a general equilibrium model. Indeed, to the best of our knowledge, general equilibrium model is the only class of model providing the appropriate framework to consider this class of interdependence. Thus, as the aims of this chapter are not (i) to challenge deeply the GA framework and (ii) to develop a general equilibrium model, we retain the main features of GA model and neglect the interdependence between health and educational attainment.

Do not include the effect of interdependence between health and skill does not mean that our longitudinal exercise provides a fake measure of fiscal gains resulting from improvement in both health and educational attainment. It just means that we develop a GA model able to assess and isolate the fiscal gains generated by, on one side, the health enhancement and, on the other sides, the improvement in educational attainment. These fiscal gains do not only include the potential fiscal gains induced by the interdependence between health and skill. We then interpret the fiscal gains resulting from the health improvement and the enhancement in educational attainment as fiscal gains generated firstly by health enhancement and secondly by educational attainment without taking into account the potential fiscal gains induced by the interdependence between health and skill.

### 3.1.4 The fiscal policy sustainability measure

To assess the fiscal gains resulting from improvement of both health and educational attainment, we evaluate the fiscal policy sustainability. For that purpose, following $CD$, we use equation (3.4) to obtain $PVL_t$, we exploit equations (3.2) and (3.3) to compute $PVG_t$ and as $W_t$ is given by the opposite of national debt, we deduce $PVF_t$ as a residual of the intertemporal budget constraint described in equation (3.1). The fiscal burden/surplus bequeathed to future generations is thus measured through $PVF_t$.

In the same line with $CD$, we establish an hypothetical generational account of each future cohort by applying the current fiscal policy on future cohort to avoid that fiscal adjustments are carried forward on future generations only. This hypothetical generational account is given by $PVF_t^*$ such that:

$$PVF_t^* = \sum_{s=t+1}^{\infty} \sum_{j=0}^{Min[s-t-1;D]} \frac{\theta_{j,s}^L p_{j,s}^L + \theta_{j,s}^M p_{j,s}^M + \theta_{j,s}^H p_{j,s}^H}{(1+i)^{s-t}} \tag{3.11}$$

Namely, $PVF_t^*$ measures the present value of net tax payments by future generations under the current fiscal policy.

By comparing $PVF_t$ and $PVF_t^*$, we deduce the sustainability of fiscal policy because:

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

Raffelhüschen (1999) proposes to assess the Intertemporal Public Liabilities ($IPL$) to determine the sustainability of fiscal policy. He defines $IPL$ as the residual of the intertemporal budget constraint, if all generations, present and future, receive the same tax treatment. Namely:

$$IPL = PVG_t - W_t - PVL_t - PVF_t^* \tag{3.12}$$

Here, we assess IPL to measure the extent of fiscal adjustment necessary to restore the fiscal balance. Following Raffelhüschen (1999) and CD, this fiscal adjustment is thereafter applied on all members of all generations. For that purpose, we compute the proportional adjustment in all taxes (resp. all transfers) required to balance the budget. First, we distinguish taxes and transfers in net tax payments of all generations such that $\theta_{j,s}^X = \theta_{T,j,s}^X - \theta_{B,j,s}^X$ with $\theta_{T,j,s}^X$ the taxes and $\theta_{B,j,s}^X$ the transfers. Second, a time-invariant adjustment factor is applied on $\theta_{T,j,s}^X$ and $\theta_{B,j,s}^X$ to restore the fiscal balance. This time-invariant adjustment factor is described by the continuum of pairs $(\eta_T, \eta_B)$ such that the adjustment rule is summarized by the following equations:

$$PVL_t^{adj} = \sum_{j=0}^{D} \sum_{k=j}^{D} \sum_{X=L,M,H} \frac{\left[\theta_{T,k,t+k-j}^X (1+\eta_T) - \theta_{B,k,t+k-j}^X (1-\eta_B)\right] p_{k,t+k-j}^X}{(1+i)^{k-j}} \tag{3.13}$$

$$PVF_t^{adj} = \sum_{s=t+1}^{\infty} \sum_{j=0}^{Min[s-t-1;D]} \sum_{X=L,M,H} \frac{\left[\theta_{T,j,s}^X (1+\eta_T) - \theta_{B,j,s}^X (1-\eta_B)\right] p_{j,s}^X}{(1+i)^{s-t}} \tag{3.14}$$

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

Thus, restoring the fiscal balance through transfers cuts implies that $\eta_T = 0$ and achieving budget balanced through taxes increases involves that $\eta_B = 0$.

## 3.2 Data issues and assumptions

The new method of GA is applied to the French economy to assess the fiscal gains resulting from health improvement of French population and to update the fiscal burden induced by population aging, estimated by Chojnicki (2013) at 200% of 2005's GDP. To undertake this longitudinal exercise, we exploit the last available data on the evolutions of French demography (section 3.2.1), skill structure of French population (section 3.2.2), French fiscal framework (section 3.2.3) and health improvement of French population (section 3.2.4).

### 3.2.1 Population forecast

Data on evolution of French population is obtained by exploiting the demographic forecast of Blanpain and Chardon (2010). More precisely, we use the intermediate population projection proposed by these authors[3]. This intermediate population forecast describes the evolution of French population between 2007 and 2060 by assuming that:

- the life expectancy at birth rises from 77.2 and 84.2 years-old for men and women in 2007 to respectively 86.0 and 91.1 years-old in 2060;
- the fertility rate remains at 1.98 children per women before 2015 and decreases at 1.95 children per women beyond this date;

[3] The intermediate population projection proposed by Blanpain and Chardon (2010) is the same as the intermediate population projection provided by INSEE, the French National Institute of Statistics and Economic Studies

- the number of persons who immigrate in France is equal to 100 000 per year until 2060.

By adopting these assumptions, Blanpain and Chardon (2010) estimate a sharp increase in old-age dependency ratio given here by the size of population aged 65 expressed as a percentage of the size of population aged 15 to 64 years-old. As outlined in Table 3.1, the old-age dependency ratio, equal to 25.3% in 2007, should reach 47% in 2060. This demographic trend confirms once again the ageing process of French population.

Table 3.1: The evolution of French population between 2007 and 2060

| | ***2007*** | ***2020*** | ***2060*** |
|---|---|---|---|
| ***Total population (× 1 000)*** | 61,795 | 65,962 | 73,558 |
| ***Population aged 15 to 64 years-old (× 1 000)*** | 40,266 | 40,704 | 41,831 |
| ***Population aged 65 and over (× 1 000)*** | 10,208 | 13,453 | 19,643 |
| ***Old age dependency ratio (+65/15-64)*** | 0,2535 | 0,3305 | 0,4696 |
| *Source:* | Blanpain & Chardon (2010) | | |

However, the time frame covered by population forecast of Blanpain and Chardon (2010) is not enough longer to undertake our longitudinal exercise. To evaluate the intertemporal sustainability of French fiscal policy, it is necessary to compute the net payments of current and future newborns generations until the end of their lives, the value of public expenditures as well as the generational accounts of future generations on a very distant horizon. That is why, we extend the Blanpain and Chardon (2010)'s projection until 2110 by assuming as usual that mortality, fertility and net migration rates remain at their 2060 level. Note that, because of the discounting effects, GA attributes a little weight to net payments of generations belonging to a fairly distant horizon. It implies that assumptions related to population evolution after 2060 are not restrictive.

### 3.2.2 The skill structure

Data on skill structure of French population are obtained by exploiting data from the last French Population Census published in 2008. By using this database, we distinguish three educational levels:

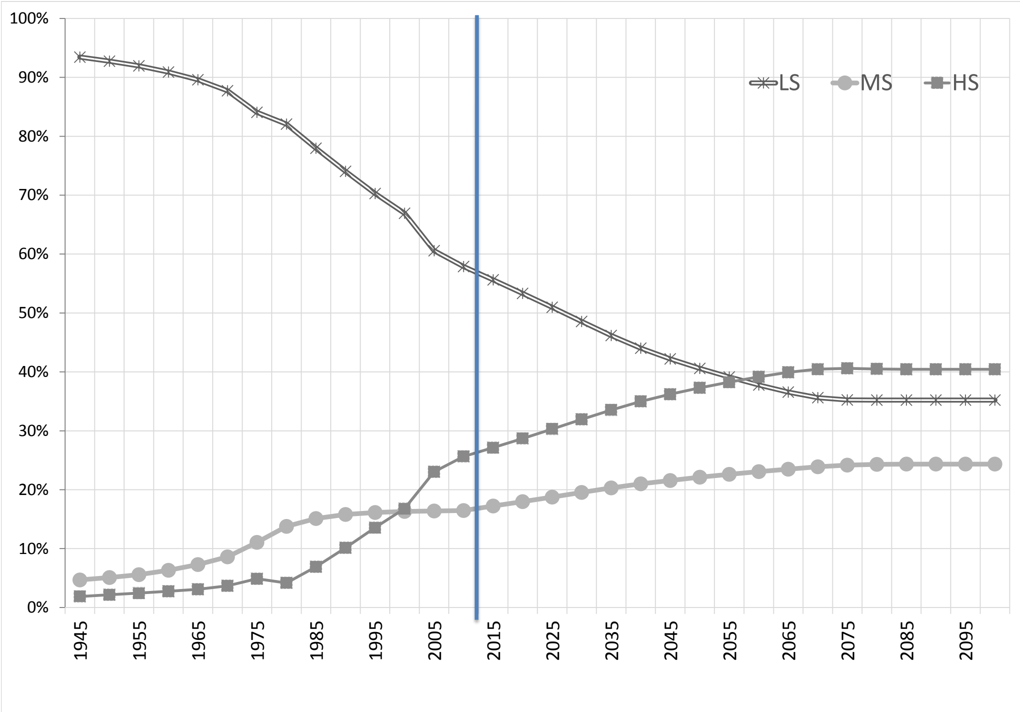
- low-skilled ($LS$) composed by agents having an educational level below *baccalauréat* (BAC)[4];
- medium-skilled ($MS$) formed by individuals obtaining BAC and making at most two years' higher education;
- high-skilled ($HS$) composed by agents making more than two years' higher education;

and obtain the skill structure of French living cohorts aged 30 and over in 2008.

As official long run forecast on future skill structure of French population is not available, we assume that skill structure in 2008 remains constant over time and apply this latter on population forecast proposed by Blanpain and Chardon (2010). The evolution of French population skill-structure obtained by adopting this assumption is illustrated in Figure 3.1. We can see that the main changes in educational attainment (measured by the share of each educational group in French population) occurred before 2008. Among the population aged 60 in 2008, the share of HS, MS and LS in French population are respectively 19.7%, 13.5% and 66.8%. Among the population aged 30 at the same period, these shares are 42.8%, 22.1% and 35.1% for respectively HS, MS and LS. Nonetheless, although we assume no more progress in educational attainment of young cohorts (those aged 30 after 2008), we can observe an future improvement in skill structure of French population due to the rise of younger cohorts, with high educational level, in French population age structure.

[4] *Baccalauréat* is the French equivalent to Higher Leaving Certificate.

Figure 3.1: Population shares by educational attainment (% of the total population)




### 3.2.3 Taxes and transfers profiles by age and educational attainment

To determine the transfers perceived by each French citizen, we consider the six main French Social Security expenditures corresponding to the different risks covered by French Social Security, namely (1) retirement, (2) health, (3) family, (4) unemployment, (5) housing, (6) poverty/exclusion. Following Chojnicki (2013), we include also education expenditures in transfers as these latter belong to age-specific transfer. To establish the taxes payed by each French citizen, we define six categories of taxes which are labor income taxes, capital income taxes, consumption taxes, local taxes, GSC/NDRC (Generalized social contribution/National Debt Repayment Contribution) and social contributions. This classification of transfers and taxes is retained to build the taxes and transfers profiles of each representative agent in each cohort. For that purpose, we exploit data from Survey on French Household Budget (referred to below as BdF11) provided by INSEE (Buron, Kranklader, and Ribera 2014). BdF11 considers

30,416 individuals dividing into five-year age slices to obtain consistent rich blocks with comparable sizes. The age and skill distributions of each tax and transfer are extracted form BdF11. Some taxes and transfers are clearly individualized like retirement, unemployment and minimum income (RMI). At the opposite, many others are only relevant at household level and require to be individualized. For these taxes (resp. transfers), we compute the total amount payed (resp. perceived) by each member of each household proportionally to its incomes. The individual profiles of GSC and NDRC are estimated by applying on the gross income the employee-employer social contributions rates depending on wage income and job occupation. The consumption tax profile is deduced by making the sum of different tax rates applying on consumption expenditures of each member of each household in BdF11. As BdF11 provides no information on capital tax profile, we assume that capital tax profile follows the capital incomes profile. The age and skill distributions on health care expenditures are provided by the Survey on Health Care carried by the Institute for Research and Information in Health Economics (referred to below as IRDES) and undertaken by Dourgnon, Guillaume, and Rochereau (2012). This survey considers 15,973 individuals. Like for BdF11, we consider five-year age slices and aggregate the individual total expenditures on health to evaluate the total cost of health care. The age and skill distributions of total cost of health care are then deduced from the total expenditures on health by age and by skill. To determine the age and skill distribution on education expenditures, data on the enrollment rates by age from French population census of 2008 are matched with data on the average expenditure per graduate from the Official Statistics of French Ministry of Education. Thus, we deduce the average cost of education by age with respect to educational attainment.

The age and skill-level distributions of total taxes, total benefits and net taxes are described in Figures 3.2, 3.3 and 3.4. It appears that educational attainment affects mainly the level of taxes payed by each cohort. At age 50, taxes paid by HS are 2.6 times greater than those paid by LS. There is no significant difference between transfers profiles of each skill. Net taxes profiles indicate that LS perceives more transfers than

Figure 3.2: Tax profile by age and educational attainment (in euros)

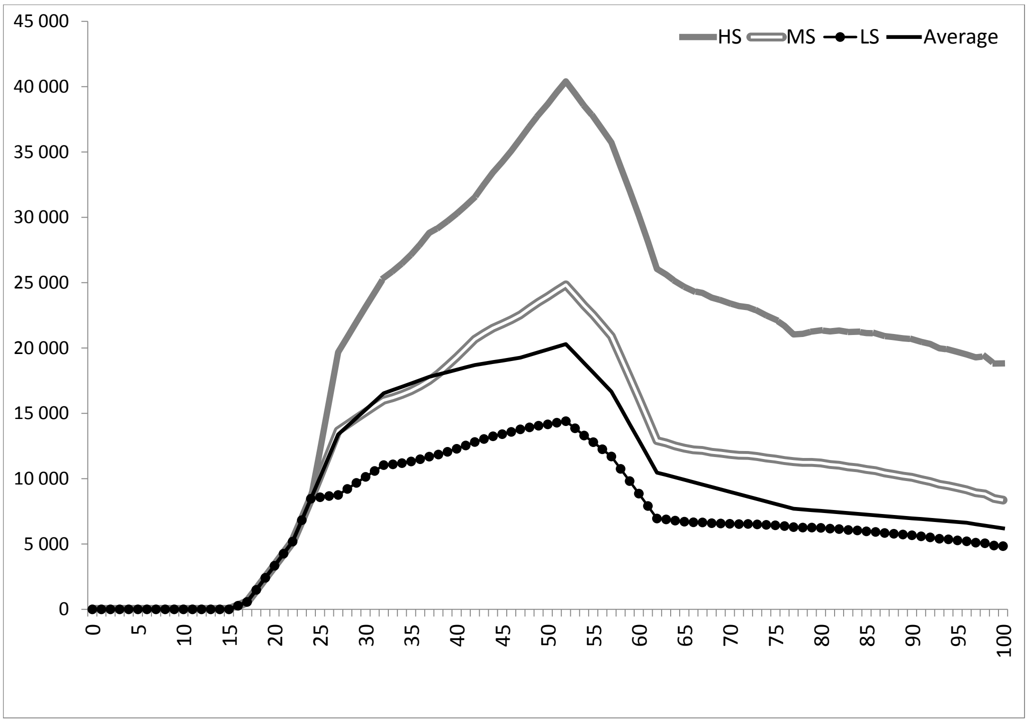



Figure 3.3: Transfer profile by age and educational attainment (in euros)

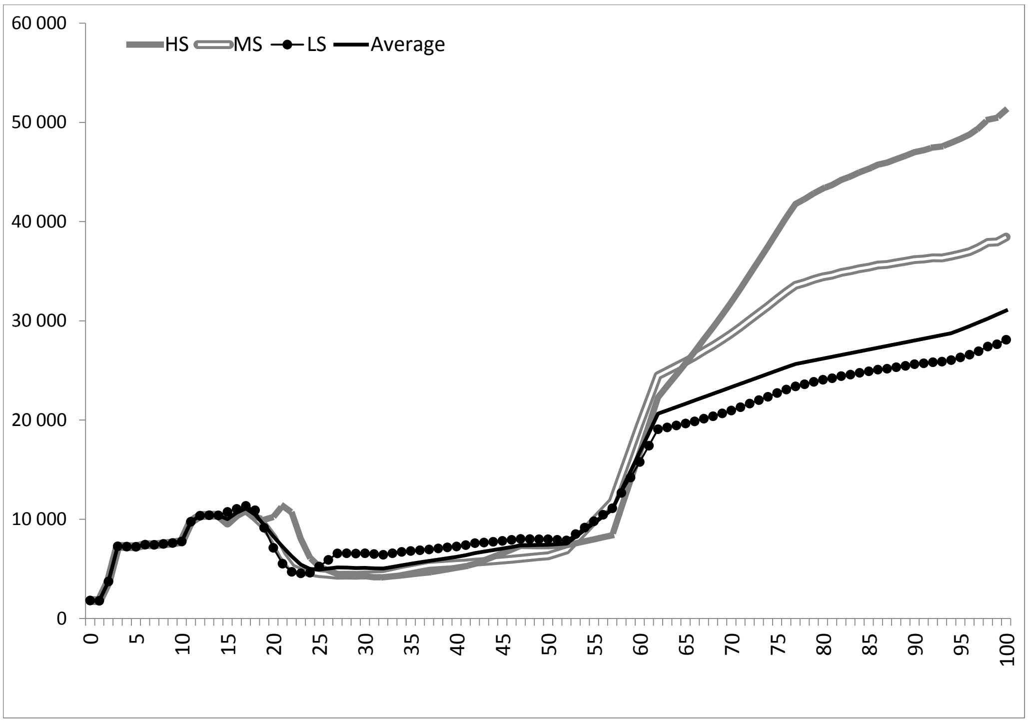
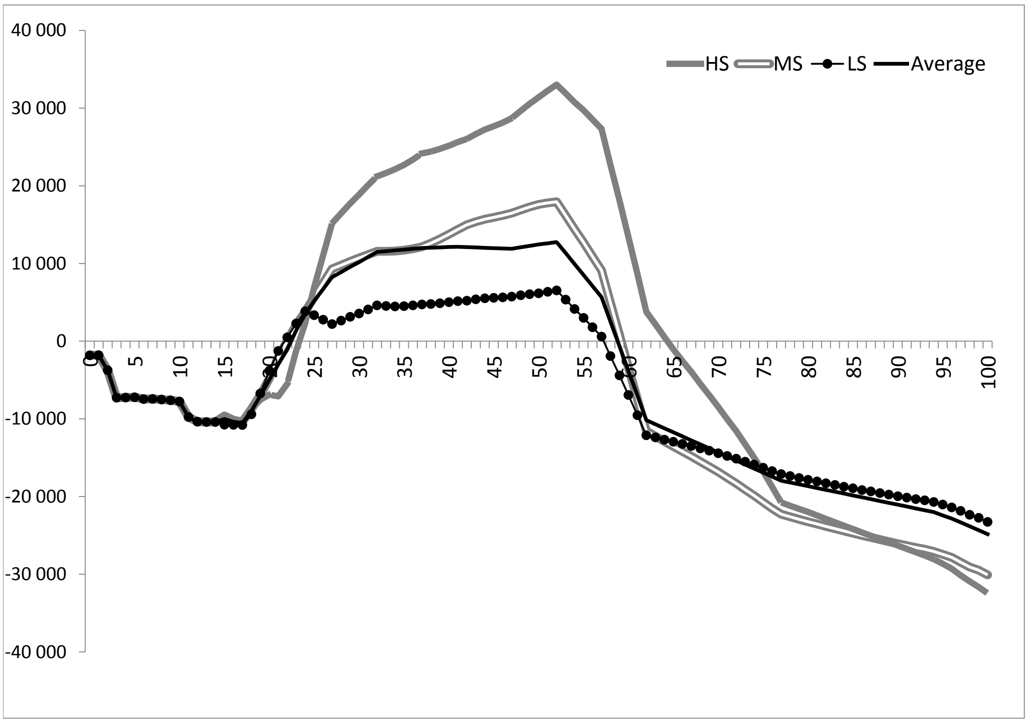


Figure 3.4: Net tax profile by age and educational attainment (in euros)




they pay taxes. At the opposite, MS and HS pay more taxes than they perceive transfers. At age 50, the ratio of net taxes between HS and MS is about 1.8 to 1.

The aggregate amounts obtained by making the weighted sum of individual tax and transfer profiles are not systematically identical to those provided by French National Accounting (INSEE 2011) and reported in Table 3.2. To offset this issue, we rescale uniformly these aggregate amounts by exploiting data from French National Accounting Report (INSEE 2011) and data on social expenditures in France collected by IRDES. To avoid that these aggregate amounts depend on the selected base year, namely 2010, we include all changes affecting French public administrations budget since 2010. Thus, we manage to equalize the aggregate amounts obtained by making the weighted sum of individual profiles on tax and transfer and the aggregate amounts recorded in French National Account.

As indicated in Introduction, the evolution of each component of French public budget is not available beyond 2012. French administration does not provide any official

Table 3.2: Public Taxes and Spending in 2010 (in Million of €)

| ***Taxes*** | ***Millions of €*** | ***% of GDP*** | ***Transfers*** | ***Millions of €*** | ***% of GDP*** |
|---:|---|---|---:|---|---|
| ***Labor income taxes*** | 43026 | 2,43 | ***Pension*** | 253579 | 14,31 |
| ***Capital income taxes*** | 34674 | 1,96 | ***Housing*** | 14960 | 0,84 |
| ***Excise taxes*** | 157535 | 8,89 | ***RMI*** | 13206 | 0,74 |
| ***Council taxes*** | 42603 | 2,40 | ***Unemployment*** | 35024 | 1,98 |
| ***GSC-NDRC*** | 80866 | 4,56 | ***Family*** | 50327 | 2,84 |
| ***Social contributions*** | 330376 | 18,64 | ***Health*** | 169460 | 9,56 |
| ***Other taxes*** | 188009 | 10,61 | ***Education*** | 124085 | 7,00 |
| | | | ***Other spendings*** | 302004 | 17,04 |
| | | | ***Interest*** | 40137 | 2,26 |
| ***Total*** | 877090 | 49,48 | ***Total*** | 1002782 | 56,57 |
| | | | ***Deficit*** | 125692 | -7,09 |

Notes: GSC: Generalised Social Contribution;
NDRC: National Debt Repayment Contribution;
RMI: Minimum Income
Source: French National Account, INSEE,
French Social Secutity Account, Drees

long term forecast on evolution of each tax and transfer in public budget. To offset this unavailability of long term forecasts in order to undertake our longitudinal exercise, we require on the traditional assumption of GA method assuming that all individual taxes and transfers evolve in the same pace with labor productivity. More precisely from 2012, we assume that labor productivity grows steadily at 1,3% per year[5] and the discount rate remains at 6%. Those assumptions explain why generational account in French economy computed with the classical method of GA is highly sensitive to value retained to indicate the productivity growth rate.

### 3.2.4 Health improvement and labor productivity growth

To obtain GA less sensitive to value retained to indicate the productivity growth rate, we give up the traditional assumption assuming that productivity grows at a constant rate over time. For that purpose, we assume that evolution of productivity follows

[5] 1.3% corresponds to labor productivity growth retained by French Pension Advisory Council in the medium variant of their middle term forecast(Conseil d'Orientation des Retraites 2012)

equation (3.9). Namely, at each period, the productivity growth rate is given by the sum of total productivity growth and health improvement weighted by its rate of returns.

**Measuring health improvement**

There is no consensus on the relevant indicator of health improvement at macroeconomic level. On one side, some authors like Sachs and Warner (1997), Bloom and Williamson (1998), Bloom, Canning, and Sevilla (2004), Acemoglu and Johnson (2007), Aghion, Howitt, and Murtin (2011), Cervellati and Sunde (2011), Barro (2013b) assess the health improvement of a given population through its increase in life expectancy at birth. This indicator is retained because these authors assume implicitly that health enhancement allows to extend life. On the other side, some authors like Bhargava, Jamison, Lau, and Murray (2001), Bloom and Canning (2005) and Weil (2007) Ashraf, Lester, and Weil (2008) measure the health improvement of a given population by the evolution of its Average Survival Rate (referred to below as $ASR$). The insight is that $ASR$ is a positive function of health improvement (Hall and Jones 2007).

Following Bhargava, Jamison, Lau, and Murray (2001), Ashraf, Lester, and Weil (2008), Bloom and Canning (2005) and Weil (2007), we approximate the health enhancement of French population by the evolution of its $ASR$. We retain the $ASR$ as health improvement indicator rather than life expectancy because the increase in life expectancy mainly reflects the expand in life of retired population. It involves that measuring the health improvement through the increase in life expectancy mainly captures the health improvement of retired population. To assess the health improvement of active population impacting labor productivity, the increase in life expectancy is then not the relevant indicator of health improvement.

At the opposite, each cohort is characterized by its survival rate. It is then possible to isolate the survival rate of active population, namely population aged between 15 and 64 years-old. Consequently, it is also possible to neglect the survival rate of retired population to exclude the potential effect of health improvement of retired population on labor productivity. Moreover, as $ASR$ is a positive function of health improvement (Hall and Jones 2007), an enhancement of active population health should increase the survival rate of this population. The evolution of active population survival rate should then reflect the evolution of active population health. That is why, the health improvement of French active population is approximated by $ASR$ in this Chapter.

To obtain the evolution of French population survival rate, we exploit the population forecast proposed by Blanpain and Chardon (2010). Indeed, to forecast the evolution of French population between 2007 and 2060, these authors compute the survival rate of each cohort between 2007 and 2060 at each period. To disaggregate these survival rates by educational level, we apply the Standardized Mortality Rates (SMR) - estimated by Mejer (2004) for each educational level - on the survival rates computed by Blanpain and Chardon (2010) between 2010 and 2060. The survival rates at each age for each skill remain at their 2060 level beyond this date, to execute the GA exercises. The survival rates of each cohort belonging to French population aged 15-64 years-old are isolated to measure the average survival rate of these cohorts at each period, namely the $ASR$. The annual growth rate of $ASR$ provides thereafter the numerical value of $g^{h,X}_{t+k-j}$ in equation (3.9) at each period. The evolution of $g^{h,X}_{t+k-j}$ over time is illustrated in Figure 3.5.

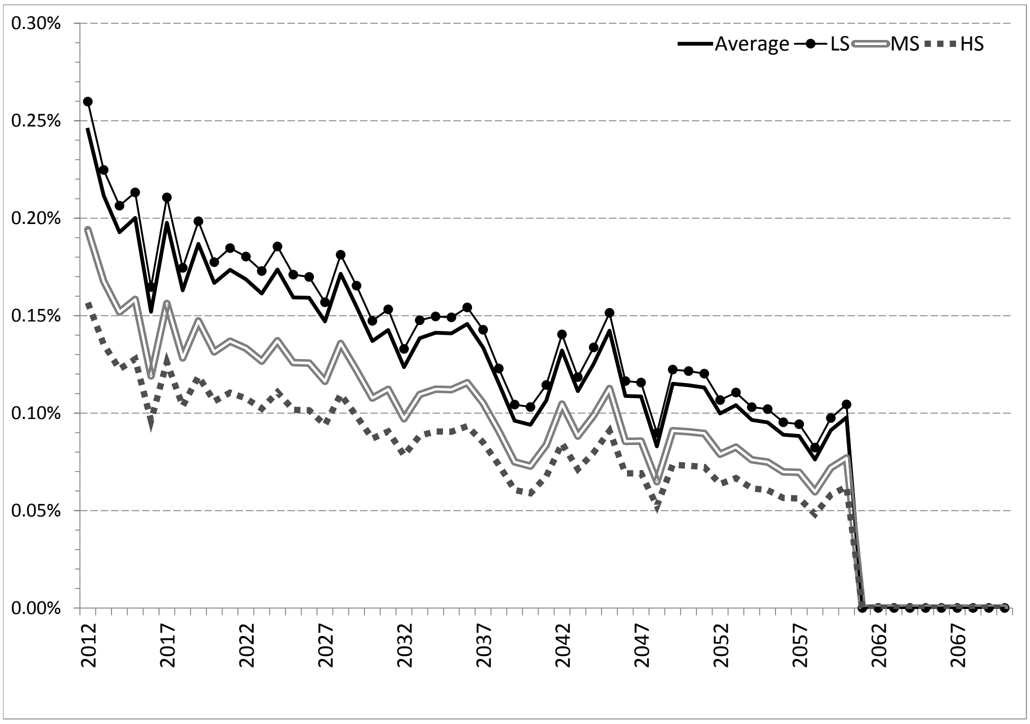
Figure 3.5 indicates that health improvement of French workforce should not be very substantial in the coming decades. Between 2010 and 2060, the growth rate of ASR should not exceed 0.5% per year. In addition, it seems that the growth rate of ASR should decrease over time. In other words, the health improvement of French workforce should also diminish over time. Note that LS's health improvement should be more important than MS and HS health enhancement. It seems that health improvement should not be shared homogenously across skills and depend negatively on skill-level.

### The evolution of productivity growth rate

As usual, the value given to $TFP$ growth rate is assumed to be constant over time and independent of skill level. In other words, we can write that $g^{A}_{t+k-j} = g^{A}$.

Figure 3.5: The evolution of growth rate of the average survival rate for each year




To provide a numerical value to $g^A$, we exploit the study undertaken by Cabannes, Montaut, and Pionnier (2013). These authors estimate the evolution of $TFP$ in France between 1979 and 2010 and evaluate that $g^A = 1.3\%$ during this period. We retain this value and assume that the average past trend on the evolution of $TFP$ in France still remain in long term. Thus, we provide a numerical value to all variables in equation (3.9) except for $\rho$.

Estimating the value of $\rho$ in France is far beyond the scope of this Chapter. That is why, we prefer to retain the value of $\rho$ obtained in well recognized studies. The study undertaken by Bloom and Canning (2005) on the impact of health improvement on economic growth in 21 OECD countries is one of these well recognized studies. Bloom and Canning (2005) assess the health improvement of workforce by its $ASR$ and estimate that an increase of $ASR$ by 0.01 could increase the productivity by 2,8%. Following this result, we assume that $\rho = 0.028$. Thus, by assuming that $g^A = 1.3\%$, $\rho = 0.028$ and by assessing $g^{h,X}_{t+k-j}$ with the annual growth rate of the $ASR$ of French workforce, we obtain in Figure 3.6 the evolution of $\gamma^X_{t+k-j}$ over time.

Figure 3.6: Labor productivity growth with productivity gains from health

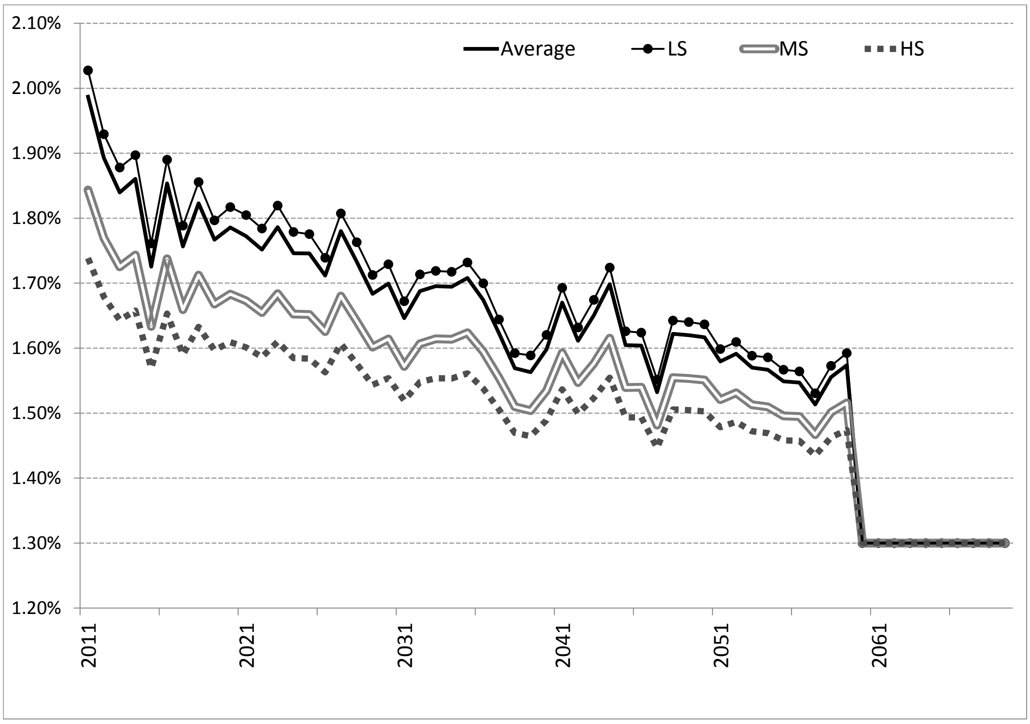



Figure 3.6 indicates that despite that health improvement of French workforce vanishes over time (Figure 3.5), this health enhancement generates nevertheless some significant productivity gains. However, this productivity gains should vanish over time. On average, the productivity growth should decrease to 1.57% in 2060 and should remain at 1,3% after 2060. It appears also that, beyond 2060, the productivity growth of French workforce should reach its long term value and French economy should evolves along its balanced growth path. After 2060, the productivity growth is the same for each skill and for each cohort, namely 1.3%.

Obviously, the evolution of $\gamma^X_{t+k-j}$ over time depends on the value of $\rho$. To evaluate the sensitivity of our results with respect to value of $\rho$, we undertake some robustness check in section 3.4. For that purpose, we exploit the value of $\rho$ obtained by Weil (2007) and Barro (2013b). Weil (2007) assess that $\rho = 0.0653$ and Barro (2013b) find that $\rho = 0.014$. These different values of $\rho$ inform that $\rho = 0.028$ is an intermediate value of $\rho$ estimated by Weil (2007) and Barro (2013b). That is why we retain $\rho = 0.028$ in our main forecast exercise. Barro (2013b) provides the last available estimation of $\rho$. However, we do not retain the value of $\rho$ estimated by this author in our main forecast exercise because he estimates the health improvement by the increase in life expectancy contrariwise to us.

## 3.3 A better assessment of human capital effects on labor productivity

Matching data described in Section 3.2 with GA model developed in Section 3.1 allows (i) to assess how much GA exercises are sensitive to assumption on productivity growth rate and (ii) to account the fiscal gains resulting from both the changes in skill structure and the health improvement of French population. For that purpose, we execute four different longitudinal exercises corresponding to four scenarios. In the first scenario (Section 3.3.1), we exploit the traditional methodology of GA developed by Auerbach, Gokhale, and Kotlikoff (1991) and obtain results forming the baseline scenario. In the second scenario (*scenario* $EA$ in Section 3.3.2), we decompose per schooling level the GA of each cohort estimated in the baseline scenario by applying the methodology developed by $CD$. The comparison of GA obtained by using the traditional method with those assessed through the method of $CD$ allows to measure the fiscal gains induced by changes in skill structure of French population. In the third scenario (*scenario* $HI$ in Section 3.3.3), we apply the revisited GA model of $CD$ described in Section (3.1) without considering the skill heterogeneity in French population to isolate the fiscal gains resulting only from health improvement. Finally, in the fourth scenario (*scenario* $EA + HI$ in Section 3.3.4), we use the revisited GA model of $CD$ by taking into account the future change in skill structure to assess the fiscal gains generated by the enhancement in both health and educational attainment of French population.

### 3.3.1 Baseline results

The results obtained with the conventional methodology of GA (Auerbach, Gokhale, and Kotlikoff 1991) are composed by (i) the generational account of living generations in 2010 summarized in the first part of Table 3.3 and (ii) the Intertemporal Public Liability (IPL) induced by the current French fiscal policy.

The GA of living generations in 2010 are obtained by using equation (3.5) and by exploiting tax and transfer profiles described in Section 3.2.3. These accounts measure the net payment (total taxes paid minus total transfers received) of each generation alive in 2010 until the end of its live, and highlight the standard result on the evolution of GA over time. According to results recorded in the first part of Table 3.3, GA increase with age in the first part of life of each cohort and reach a peak at 25 years-old. The combination of the decrease in remainder time devoted to job activities and the lower discount on expenditures tied to old age (retirement, health care and disability) induces a reduction of GA after 25 years-old. GA become negative at around 50 years-old and reach a minimum at around 70 years-old. After this age, GA increase anew due to the reduction in remainder time to live.

By matching equation (3.11) with data in Section 3.2.3, we compute the hypothetical GA of future generations by assuming that the current fiscal policy, which is effective on living cohorts, is also applied on future cohorts. By combining these hypothetical GA with French government intertemporal budget constraint described in equation (3.1), we provide the numerical values to all variables in equation (3.4) and deduce the IPL. We estimate then that French IPL should be on the order of 129.64% of 2010's GDP if French fiscal policy is not changed. Thus, according to this longitudinal exercise, the net current and future payments (i) are negative, (ii) should further increase the current level of French national debt and (iii) explain why the current fiscal policy is not sustainable in long term[6].

As the discounted value of net payments of present and future generations is not

[6]The prospective net payments over the life cycle of newborn in 2010 illustrates how the future payments will increase the current level of the national debt. Indeed, according to Table 3.3, on average this cohort will receive more over its life cycle than he contributes.

Table 3.3: Generational accounts of living generations

| | Present value of taxes | Present value of benefits | Generational accounts |
|---|---|---|---|
| | | ***Baseline scenario*** | |
| **0** | 136160 | -169311 | -33152 |
| **20** | 316066 | -157581 | 158485 |
| **30** | 368435 | -174487 | 193948 |
| **40** | 326851 | -197295 | 129556 |
| **50** | 251563 | -227915 | 23648 |
| **60** | 146206 | -281375 | -135169 |
| **70** | 97261 | -249417 | -152156 |
| **100** | 6261 | -26473 | -20212 |
| | | ***GA with educational attainment*** | |
| | | ***Weighted average*** | |
| **0** | 150518 | -169542 | -19024 |
| **20** | 350205 | -164598 | 185607 |
| **30** | 429982 | -181813 | 248169 |
| **40** | 373254 | -208746 | 164508 |
| **50** | 269172 | -238824 | 30348 |
| **60** | 159301 | -295463 | -136162 |
| **70** | 100956 | -260498 | -159543 |
| **100** | 6238 | -26916 | -20678 |
| | | ***Low Skill*** | |
| **0** | 91126 | -171041 | -79915 |
| **20** | 210137 | -165436 | 44700 |
| **30** | 234784 | -188893 | 45892 |
| **40** | 213695 | -196872 | 16823 |
| **50** | 166032 | -214892 | -48860 |
| **60** | 97720 | -255669 | -157949 |
| **70** | 70947 | -225139 | -154193 |
| **100** | 4544 | -23579 | -19034 |
| | | ***Medium Skill*** | |
| **0** | 136958 | -163037 | -26079 |
| **20** | 318257 | -151014 | 167242 |
| **30** | 379073 | -175858 | 203216 |
| **40** | 362409 | -209835 | 152575 |
| **50** | 294725 | -265226 | 29499 |
| **60** | 178983 | -348901 | -169918 |
| **70** | 128208 | -324091 | -195883 |
| **100** | 8015 | -33861 | -25846 |
| | | ***High Skill*** | |
| **0** | 210392 | -172151 | 38241 |
| **20** | 491391 | -172043 | 319348 |
| **30** | 617990 | -179087 | 438903 |
| **40** | 601338 | -224750 | 376588 |
| **50** | 517772 | -282909 | 234863 |
| **60** | 347381 | -389350 | -41969 |
| **70** | 246507 | -403625 | -157118 |
| **100** | 17717 | -46476 | -28759 |

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

able to cover the total public consumption and the current national debt, some fiscal adjustments are necessary. The magnitude of these fiscal adjustments is estimated by exploiting equations (3.13) and (3.14) that provide the proportional adjustment in all taxes and/or transfers applied on living and future cohorts to balance the budget by assuming that all changes begin in 2010. According to our calculation, a proportional increase in tax rate by 13.46% or a decrease in all transfers by 14.55% applied on living generations in 2010 and on future generations are required to restore the budget balance in long term. The tax adjustment should increase the net contribution of a newborn in 2010 by approximately 18,322€ and the transfer adjustment should rise this net contribution by approximately 21,357€.

Table 3.4: Intertemporal budget constraint equilibrium: baseline scenario

| | |
|---|---|
| **New born generational account** | -33152 |
| **Implicit debt (in % of 2010 PIB)** | 66% |
| **Explicit net debt in 2010 (in % of 2010 PIB)** | 63,63% |
| **IPL (in % of 2010 PIB)** | 129,6% |
| | |
| **Tax adjustment** | 13,46% |
| **Adjusted new born generational account** | -14830 |
| | |
| **Transfer adjustment** | -14,55% |
| **Adjusted new born generational account** | -8512 |
| | |
| **Tax and transfer adjustment** | 6,99% |
| **Adjusted new born generational account** | -11795 |

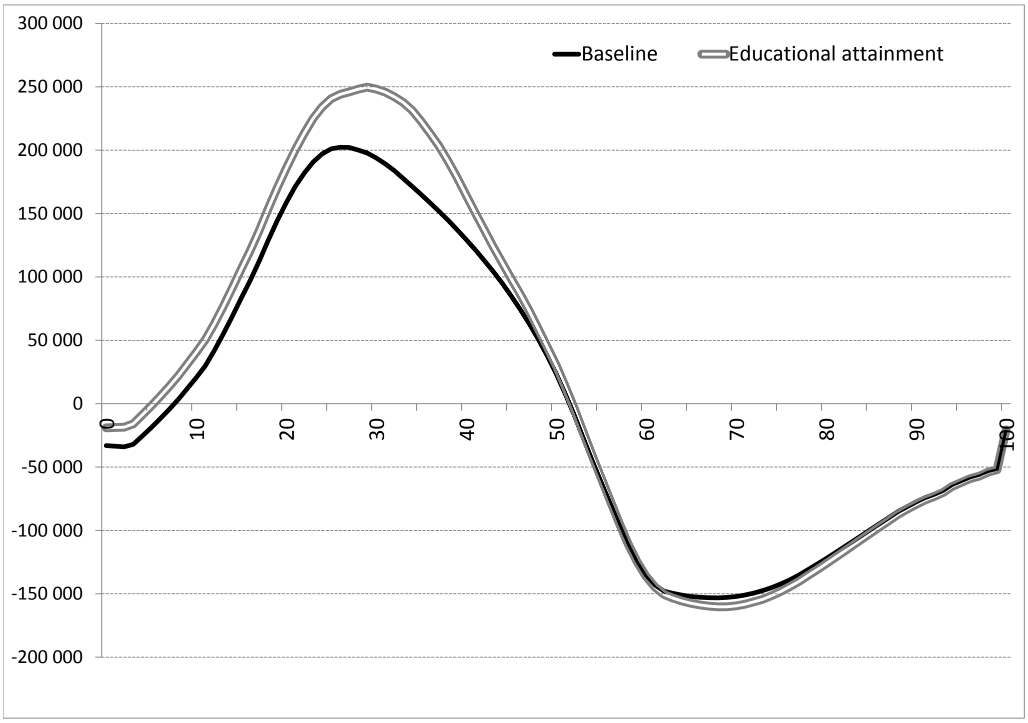
Source: Authors' calculations

### 3.3.2 Generational accounts and educational attainment

By applying the methodology developed by Chojnicki and Docquier (2007), we decompose per schooling level the GA of each cohort estimated in the first part of Table 3.3. The GA by skill level of living generations in 2010 are summarized in the second part of Table 3.3 and highlight that GA vary significantly across skills. The GA of LS are negative under 16 years-old and after 45 years-old, while this is true before 7 years-old and after 52 years-old for MS and only after 58 years-old for HS. Moreover, the GA of HS, over their whole lifetime, are positive. At the opposite, the GA of LS and MS are negative over their whole lifetime[7]. Note that the average GA of LS newborn are estimated to be three times lesser than the one of MS newborn.

This GA heterogeneity across skill-level and the changes in skill structure of living cohorts affect significantly the average GA per cohort. The average GA per cohort estimated with $CD$'s method are not identical to those given by the standard methodology of GA (see Table 3.3). By only extrapolating the future taxes and transfers of newborns by referring on the current profile, the classical method underestimates newborns' average account by 74% (-33,152€ compared with -19,024€ ).

Figure 3.7: The average generational account per living cohort: baseline vs. educational attainment (Present value in 2010 euros)




The future changes in skill structure of French population[8] affects also the sus-

[7]According to the second part of the Table 3.3, LS and MS are expected to receipt more transfers than they pay taxes over their whole lifetime

[8]As it is explained in Section 3.2.2, in this scenario we extrapolate the educational attainment of future generations by referring on those who leave the school system in 2010.

tainability of French fiscal policy. We estimate that the future rise in educational attainment of younger generations should generate lower IPL than in our baseline scenario even if French government applies the current fiscal policy on future cohorts. IPL decreases by 63% compared to IPL in the baseline (see Table 3.5).

However, the current fiscal policy remains unsustainable in long term. In other words, the fiscal gains generated by the future changes in skill structure are not enough to remove the fiscal burden induced by French population aging. Restoring the budget balance through tax adjustment implies a rise in all taxes by 4.53% (see Table 3.6). It appears that this tax adjustment affects more heavily skilled agents (MS and HS) than unskilled one. The newborns' GA of LS, MS and HS after this tax adjustment do not change uniformly across skills. Newborns' GA of LS, MS and HS after the tax adjustment are equal respectively to -75,792€ , -19,881€ and 47,762€ . At the opposite, restoring the balance through transfer adjustment induces a cut in all transfers by 5.28%. Newborns' GA after this transfer adjustment are equal to -70,880€ , -17,466€ and 47,335€ for respectively LS, MS and HS. These results contrast with those provided by the traditional method and suggesting to increase all taxes by 13.46% or reduce all benefits by 14.55% to restore the generational balance. This second longitudinal exercise illustrates the huge potential fiscal gains resulting from the future rise in educational attainment in France.

Table 3.5: Intertemporal public liabilities and fiscal adjustments in each scenario

| | **IPL (% of GDP in 2010)** | **Tax change** | **Transfer change** | **Tax & Transfer change** |
|---|---|---|---|---|
| **Baseline scenario** | 129,64% | 13,46% | -14,55% | 6,99% |
| **Educational attainment (EA)** | 48,53% | 4,53% | -5,28% | 2,44% |
| **Health Improvment (HI)** | 108,22% | 10,35% | -11,52% | 5,45% |
| **EA + HI** | 26,76% | 2,34% | -2,79% | 1,27% |

Source: Authors' calculation

Table 3.6: Generational imbalance: Educational attainment scenario

| | **Present value of taxes** | **Present value of benefits** | **Generational accounts** |
|---|---|---|---|
| | ***Newborns' generational account*** | | |
| **LS** | 91126 | -171041 | -79915 |
| **MS** | 136958 | -163037 | -26079 |
| **HS** | 210392 | -172151 | 38241 |
| | ***Restoring the balance through tax adjustment (+4.53%)*** | | |
| **LS** | 95249 | -171041 | -75792 |
| **MS** | 143156 | -163037 | -19881 |
| **HS** | 219913 | -172151 | 47762 |
| | ***Restoring the balance through transfer adjustment (-5.28%)*** | | |
| **LS** | 91126 | -162006 | -70880 |
| **MS** | 136958 | -154425 | -17466 |
| **HS** | 210392 | -163057 | 47335 |

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

### 3.3.3 Generational accounts and health

To estimate the fiscal gains resulting from health improvement of French population, we execute the revisited GA model of $CD$ described in Section (3.1) without considering the skill heterogeneity. The results of this third longitudinal exercise are summarized in Table 3.7. It appears that not including the improvement in health status in evolution of individual productivity underestimates the newborns' GA by 8,341€. Newborns' GA in baseline scenario and in *scenario HI* are respectively equal to -33,152€ (see Table 3.4) and -24,811€ (see Table 3.7). It seems that the traditional method, by assuming an exogenous productivity growth, underestimates the newborns' average account by about 33.62%.

However, the impact of health improvement on GA seems to be less pronounced than the benefit effect from the rise in educational attainment but this impact is not negligible. The fiscal gains resulting from health improvement of French population allows to reduce the IPL by only 16.52% compared to baseline scenario (Table 3.5) while fiscal gains induced by changes in skill structure decreases the IPL by 62.57%

compared to baseline. Despite the fiscal gains resulting from health enhancement, French fiscal policy remains unsustainable in long run. Nevertheless, the necessary adjustments in taxes or transfers to restore the balance are not relatively close to those required in baseline scenario. According to our results, to restore the budget balance, by taking into account the fiscal gains induced by health improvement, the government should increase all taxes by only 10.35% (+13.46% in baseline scenario) or cut all benefits by only 11.52% (-14.55% in baseline scenario). Thus, through this third longitudinal exercise, we manage to estimate the fiscal gains resulting from the health improvement of French population. Unfortunately, in this scenario, we measure the fiscal gains induced by the enhancement in only one component of human capital.

Table 3.7: Generational imbalance: Health Improvement scenario

| ***Newborns'*** | | |
|---|---|---|
| **Present value of taxes** | **Present value of benefits** | **Generational accounts** |
| 157415 | -182226 | -24811 |
| ***Restoring the balance through tax adjustment (+10.35 %)*** | | |
| 173712 | -182226 | -8514 |
| ***Restoring the balance through transfer adjustment (-11.52%)*** | | |
| 157415 | -161234 | -3819 |

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

### 3.3.4 Generational accounts and human capital

To measure the fiscal gains resulting from the simultaneous improvement in the two main components of human capital, i.e health and skill, we enforce the revisited GA model of $CD$ described in Section (3.1) by considering the skill heterogeneity. This scenario goes beyond a simple linear combination of the two previous scenarios because the productivity growth induced by changes in survival rate depends on skill level like it is illustrated in Figure 3.6.

It seems that the fiscal gains generated by productivity gains resulting from simultaneously the health improvement and changes in skill structure of French population should reduce IPL by 102.8 points compared to baseline scenario. This result on long-term imbalance is less disturbing to those obtained by considering only the impact of the rise in educational attainment and only the effect of health improvement. IPL in *scenario* $EA + HI$ (IPL=26.76%) is (i) 21.77 points lower than IPL in *scenario* $EA$ (IPL=48.53%) and (ii) 81.46 points lower than the one in *scenario* $HI$ (IPL=108.22%). The fiscal adjustments necessary to restore the balance imply then a rise in all taxes by about 2.34% (against 4.53% and 10.35% in respectively *scenario* $EA$ and *scenario* $HI$) and a cut in all transfers by about 2.79% (against 5.28% and 11.52% in respectively *scenario* $EA$ and *scenario* $HI$).

Table 3.8: Generational imbalance: Educational attainment and Health improvement scenarios

| | **Newborns' generational account** | |
|---|---|---|
| | **EA** | **EA&HI** |
| **LS** | -79915 | -79236 |
| **MS** | -26079 | -18616 |
| **HS** | 38241 | 51326 |
| | ***Restoring the balance through tax adjustment (+7.85%)*** | ***Restoring the balance through tax adjustment (+5,39%)*** |
| **LS** | -75792 | -76755 |
| **MS** | -19881 | -15021 |
| **HS** | 47762 | 56739 |
| | ***Restoring the balance through transfer adjustment (-9.04%)*** | ***Restoring the balance through transfer adjustment (-6.37%)*** |
| **LS** | -70880 | -74066 |
| **MS** | -17466 | -13807 |
| **HS** | 47335 | 56353 |

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

*Scenarios* $HI$ and $EA + HI$ illustrate also the sensitivity of GA exercises applied on French economy to assumption on productivity growth. Results in *scenario* $HI$ underline that by assuming a constant growth rate of labor productivity over time, baseline scenario overestimates the IPL by 16.52% (129.64% vs. 108.22%). Results in *scenarios* $EA$ and $EA + HI$ illustrate that including changes in skill structure in

GA exercise is not enough to accurate the measure of IPL. Taking into account the skill heterogeneity by assuming a constant growth rate of labor productivity overestimates the IPL by 21.77 points (48.53% vs. 26.76%). Thus, the revisited GA model of $CD$ described in Section 3.1 allows (i) to measure the sensitivity of fiscal burden to assumption on productivity growth rate and (ii) to account the potential productivity gains resulting from health improvement through fiscal gains generated by this latter.

## 3.4 Sensitivity analysis

The GA exercise is sensitive to assumptions on demographic changes, discount rate, future trends in educational attainment and rate of returns of health improvement on productivity. To check the robustness of the previous results, we execute the revisited GA model of $CD$ described in Section 3.1 by using alternative assumptions on the differential in net tax payments across skills in Section 3.4.1, on changes in skill structure of French population in Section 3.4.2 and on discount rate and rate of returns of health on labor productivity in Section 3.4.3.

### 3.4.1 Skill premium forecasts

In *scenarios* $EA$ and $EA + HI$, we undertake our longitudinal exercise by assuming that changes in skill structure of French population do not affect the wage distribution across skills. However, one could think that the rise in educational attainment could reduce the wage gap between HS and LS workers in future due to the increase in share of HS workers in active population in long term. Unfortunately, GA model does not provide the appropriate framework allowing to analyze the overall impact of the rise in skilled labor supply on relative wages. Moreover, assessing the overall effect of changes in skill structure on wage distribution across skills goes beyond the scope of this chapter.

Nevertheless, we provide in this Section a robustness check of our previous results by considering an exogenous change in wage distribution across skills. More precisely, we assume that the improvement in skill structure pushes skill premium down and we check changes in results with this decrease in skill premium. For that purpose, we execute the same longitudinal exercise like in *scenario* $EA + HI$ but we suppose that (i) the tax profile of MS workers is kept constant, (ii) the LS relative to MS gap in tax profile increases by 5% and (iii) the HS relative to MS gap in tax profile decreases by 5%. In other words, the HS to LS gap in tax profile decreases by 10 percent in this robustness test[9]. These changes are introduced progressively and linearly to obtain the total reduction in wage inequality in 2060.

The results are summarized in Table 3.9 and show that LS, MS and HS newborns' GA do not vary significantly with variation in skill premium. However, the change in skill premium rises the generational imbalance and requires to increase all taxes by 3.06% (instead of 2.34% in the *scenario* $EA+HI$) or to diminish all transfers by 3.63% (instead of 2.79% in the *scenario* $EA+HI$) to restore the balance. Nonetheless, these fiscal adjustments are still much smaller than those required in baseline scenario (see Section 3.3). We can conclude that our results in Section 3.3.4 are quite robust to assumptions on skill premium forecasts.

### 3.4.2 The skill structure of future cohorts

To check the sensitivity of our results to assumption on changes in skill structure of French population, we enforce the same longitudinal exercise as in *scenario* $EA + HI$ but by assuming a more optimistic alternative forecast on skill structure. Indeed, in *scenarios* $EA$ and $EA + HI$, we just consider that skill composition of cohort aged 30 in 2010 remains constant over time and occurs also on future generations. In others words, in these scenarios, the skill structure of future cohorts is kept stationary beyond 2010[10].

At the opposite, our optimistic alternative forecast is based on the Lisbon Strategy

[9] Assuming a larger change would be rather inconsistent with our assumption about the schooling decisions of future cohorts.

[10] Among individuals who have finished their schooling activities in 2010, the share of LS, MS and HS workers are respectively 35%, 22% and 43% in this scenario.

Table 3.9: Sensitivity of generational accounts and budgetary adjustments to skill structure

| | **EA & HI** | **Lower skill premium & HI** | **Better skill HI** |
|---|---|---|---|
| | | ***Newborns' generational account*** | |
| **LS** | -79236 | -79236 | -78749 |
| **MS** | -18616 | -18616 | -18145 |
| **HS** | 51326 | 51326 | 51820 |
| | | ***Restoring the balance through*** | |
| **Tax change** | 2,34% | 3,06% | -1,52% |
| **Transfer change** | -2,79% | -3,63% | 1,89% |
| | | **Newborns' generational account after policy adjustment** | |
| | | ***Taxes*** | |
| **LS** | -76755 | -71905 | -80365 |
| **MS** | -15021 | -13905 | -20486 |
| **HS** | 56739 | 48937 | 48295 |
| | | ***Transfer*** | |
| **LS** | -74066 | -68552 | -82242 |
| **MS** | -13807 | -12360 | -21392 |
| **HS** | 56353 | 48666 | 48426 |

Note: - HI for scenario in which we take into account the effect of health improvement on labor productivity
- Present value in 2010 euros

Source: Authors' calculations

suggesting that from 2020, 50% of each generation should have made 2 years of higher education after Higher Leaving Certificate. To include the Lisbon Strategy in our longitudinal exercise, we assume that the share of HS workers aged 30 reaches 50% of active population in 2020 against 17.5% for LS workers and 32.5% for MS. Table 3.9 summarizes results obtained with this new skill structure and underlines that the newborns' GA are quite stable. This better skill structure allows also to generate fiscal surplus in long term. Due to this fiscal surplus, French government should reduce all taxes by -1.52% (against +2.34% in *scenario* $EA + HI$) and should increase all transfers by +1.89% (against of -2.79% in *scenario* $EA + HI$). This robustness check emphasizes the crucial role of education policies in debate on aging and public finance.

Obviously, improving the skill structure of French population in the spirit of Lisbon Strategy should require probably much more expansionary education policy which could modify the marginal cost of education. Higher marginal cost of education could increase the discounted cost of education with respect to the discounted gains of education and could annihilate the fiscal gains generated by the better skill structure. Unfortunately, GA exercise does not provide the appropriate framework to consider this mechanism.

### 3.4.3 Discount rates and health effects on productivity

GA exercises are also sensitive to assumption on discount rate. The value of discount rate determines the relative weight allocated to the future net payments with respect to the current ones. Unfortunately, there is no consensus on the appropriate discount rate retained in any longitudinal exercise. In our GA exercises, we just assume that the discount rate is equal to 6%. To check the robustness of our previous results, we execute then other longitudinal exercises with *scenario* $EA + HI$ by assuming two different values of interest rate which are 5% and 7%. The results of this robustness check are reported in Tables 3.10 and 3.11. It appears that the different values of discount rates significantly change the newborns generational accounts but that's to be expected in such longitudinal exercise. (see Table 3.10). For cons, the differences in results between the baseline and EA&HI scenarios, obtained by including the rise in average human capital in GA model, are extremely stable. The same conclusion can be established concerning the necessary fiscal policy adjustments: the inclusion of human capital improves substantially the assessment of fiscal policy sustainability (see Table 3.11).

Table 3.10: Sensitivity of EA&HI scenario to actualization rate and influence of health on productivity ($\rho$) (1)

| | ***Newborns' generational account*** | | |
|---|---|---|---|
| | ***i=0.05*** | ***i=0.06*** | ***i=0.07*** |
| | ***(Baseline)*** | | |
| | -13490 | -33152 | -44813 |
| | **LS (EA&HI)** | | |
| ***rho=0.014*** | -81642 | -79655 | -76990 |
| ***rho=0.028*** | -80080 | -79236 | -77247 |
| ***rho=0.0653*** | -74400 | -77210 | -77400 |
| | **MS (EA&HI)** | | |
| ***rho=0.014*** | 2657 | -22494 | -37608 |
| ***rho=0.028*** | 9293 | -18616 | -35426 |
| ***rho=0.0653*** | 29508 | -6695 | -28610 |
| | **HS (EA&HI)** | | |
| ***rho=0.014*** | 109291 | 44598 | 5326 |
| ***rho=0.028*** | 120461 | 51326 | 9361 |
| ***rho=0.0653*** | 153394 | 71220 | 21346 |

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

Concerning the impact of heath on productivity, we retain in our benchmark simulation the intermediate value from the study of Bloom and Canning (2005) ($\rho$=2.8%). We now test the sensitivity of our results to alternative value of $\rho$ by using estimations providing by Weil (2007) ($\rho = 6.53\%$) and Barro (2013b) ($\rho = 1.4\%$). Given that we have underlined earlier the significant impact of workers health improvement on their productivity, we naturally observe here a substantial variation of our results induced by a variation of $\rho$ (Table 3.10). For a given discount rate, the required increase in taxes changes from about 4 points for the different value of $\rho$. However, it does not affect the significance of fiscal gains resulting from the better health status in the as-

Table 3.11: Sensitivity of EA&HI scenario to actualization rate and influence of health on productivity ($\rho$) (2)

| | **Restoring the generational balance through...** | | |
|---|---|---|---|
| | ***i=0.05*** | ***i=0.06*** | ***i=0.07*** |
| | ***Tax change (Baseline)*** | | |
| | 10.99% | 13.46% | 15.48% |
| | ***Tax change (EA&HI)*** | | |
| ***rho=0.014*** | 0.08% | 3.42% | 6.21% |
| ***rho=0.028*** | -1.05% | 2.34% | 5.19% |
| ***rho=0.0653*** | -3.87% | -0.40% | 2.59% |
| | ***Transfer change (Baseline)*** | | |
| | -12.03% | -14.55% | -16.62% |
| | ***Transfer change (EA&HI)*** | | |
| ***rho=0.014*** | -0.10% | -4.03% | -7.22% |
| ***rho=0.028*** | 1.28% | -2.79% | -6.09% |
| ***rho=0.0653*** | 4.87% | 0.49% | -3.11% |

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

sessment of fiscal policy sustainability. This leads rather to identify the type of health expenditures able to increase efficiently the productivity level of workforce.

## 3.5 Conclusion

It is usually argued that the expected demographic changes threaten the sustainability of fiscal policies. And yet, assessing the economic costs of population aging is not easy to achieve for two main reasons. First, an important part of aging economic effects are still ahead of us and have to be evaluated with a large degree of uncertainty. Second, many channels through which the demographic mutation could affect the economy are really complex and do not allow to settle the debate on the positive or negative economic impacts of population aging.

Generational accounting is generally perceived as a meaningful way to evaluate the fiscal policy. All studies using this tool reveal a large generational imbalance generated by population aging and call for significant reform of fiscal policy. However, these studies do not take into account the positive effects of aging in terms of human capital accumulation. These positive effects are budgetary significant since it greatly modifies the fiscal means and needs of successive cohorts. Thereby, a rise in educational attainment of the successive generations could affect the labor productivity growth rate and thus influence the average age profile of taxpayers and transfers recipients over time. In parallel, while health improvement at any age contributes to population aging, this health status enhancement could also be an asset to the economy. Indeed, longer life could be likened to a rejuvenation of labor force that should improve the productivity of individual workers.

In this Chapter, we show that including the future change in skill structure of population and the future improvement of population health affect substantially the results providing by GA. Therefore, we estimate that the future change in skill structure of French population and the improvement of its health in long term could reduce by 79% the tax burden bequeathed to future generations. These results are quite robust to our assumption about future returns to skill, interest rates and the impact of health improvement on workforce productivity. However, our results are more sensitive to assumptions about the educational structure of future cohorts.

Is that a sufficient reason to give up the very negative view of the impact of aging on public finances ? We should remain cautious with the scope of our results. We should bear in mind that GA is a purely mechanical tool. It does not take into account all interdependencies between demography and economy. In reality, there are many economic impacts of aging through many different mechanisms that are not taken into account by our model of partial equilibrium. Thus, the main contribution of this study is to show how far the effects of aging on fiscal policy in long term is sensitive to assumptions on human capital accumulation. Therefore, integrating generational accounts, human capital and fiscal policy within a general equilibrium framework is obviously a promising issue which will be studied in the next Chapter.

# Chapter 4

# The long term potential benefit effects from the future increase in health spending on the French economy[1]

This Chapter attempts to provide an unified framework allowing to measure accurately the economic consequences of population aging by considering (i) health improvement allowing this demographic change and (ii) the effects of better health on mortality, well-being and labor productivity. For that purpose, we develop an Applied General Equilibrium Model with twenty overlapping generations (referred to below as AGEM-OLG) and four various types of agents (individuals, firms, public sector and private health insurance). We consider the effect of health on individual well-being like in Hall and Jones (2007). We take into account the impact of health on labor productivity by assuming that human capital is composed by health status, experience and education. Finally, we consider the effect of health on demography by assuming that, like Hall and Jones (2007), the survival rates depend endogenously on individual health status.

[1]This Chapter is joint with Xavier CHOJNICKI and Lionel RAGOT and refers to Chojnicki, Rabesandratana, and Ragot (2015)



Moreover, we consider the effect of health spending on state of health. By distinguishing public and private health spending, we are then able to analyze the simultaneous effects of health expenditures on well-being, labor productivity and demography. We attach much more attention on the effects of health spending on well-being, labor productivity and demography for two reasons. First, as suggested in theoretical economic literature, health spending significantly determine health status affecting mortality, well-being and labor productivity. We then offer an unified framework considering the simultaneous effect of health spending on mortality, well-being and labor productivity to analyze and quantify the overall effects of health expenditures on economy. Second, as indicated in General Introduction, health expenditures have substantially increased over time and should continue to follow this positive trend in the coming decades. By simulating our AGEM-OLG, we then quantify how far the future increase in health spending should explain the future evolution of mortality, well-being and labor productivity.

To be consistent with Chapter 3, we apply our AGEM-OLG to the French economy. We then build a benchmark scenario (referred to below as baseline) based on French official demographic forecasts (Blanpain and Chardon 2010). The baseline scenario describes the features of French economy when the share in GDP of all public transfers, except pension expenditures, and taxes remain at their 2015's level in the coming decades. Thereafter, we build one alternative scenario in which the evolution of health spending follows the official forecasts on health expenditures (HCAAM 2013). This first variant provides the main characteristics of French economy if health expenditures evolve as indicated by HCAAM (2013). The comparison between the baseline and the first variant is exploited to quantify the effect of the future increase in French health spending on mortality, well-being and labor productivity. It appears that the potential life gains resulting from the future increase in health spending are not substantial. In average, these life gains should not exceed 2 months in long term. Moreover, the potential productivity gains allowed by health improvement should not be enough to generate more potential economic growth compared to baseline. In other words, the productivity gains resulting from the health improvement should not be enough to annihilate the negative effects of French population aging. We obtain these results because the increase in health spending imply a crowding-out effect.

Two elements could explain this crowding-out effect. The first one is the way of financing the health spending. Indeed, a large part of health spending is financed by active population in France. Reducing the fiscal burden carried by active population to finance health spending should then annihilate the crowding-out effect. To verify the relevance of this hypothesis, we build a second variant (scenario 2) in which the future increase in health spending is mainly financed by French retired population. However, despite of this change in the way of financing the health spending, the simulation outcomes reveal that the crowding-out effect should always occur. The second element which could explain the crowding-out effect is the origins of health spending. In France, health expenditures have three origins. Health spending come from public and private health insurances, and from out-of-pocket. However, these three types of health spending do not necessarily generate a crowding-out effect. To identify the health expenditures inducing a crowding-out effect, we build three additional variant scenarios (scenarios 3, 4 and 5). Scenario 3 assumes that the future increase in health spending is principally driven by public health expenditures. Scenario 4 assumes at the opposite that the future increase in health spending is determined by the expand in private health spending. Finally, scenario 5 supposes that only out-of-pocket expenditure on health drive the future increase in health spending in France. It appears that higher is the share of public health spending in total health expenditures, higher is the crowding-out effect. At the opposite, high share of out-of-pocket expenditure on health in total health spending reduces substantially the crowding-out effect. That is the reason why the future increase in public health spending in France should induce less economic economic growth compared to baseline in the coming decades.

The evolution of public health spending over time shows that its future increase should be less important than its past increase (HCAAM 2013). Thus, by linking this past evolution of public health expenditures with the results obtained with our AGEM-OLG, the following question emerges. Would French past economic growth be more important compared to baseline if public health spending was less important during the past decades ? To answer this question, we develop two counterfactual scenarios in which the evolution of health spending during the last decades differs to the one informed in official statistics. In the first counterfactual scenario, we assume that the share in GDP of total health expenditures remain stable after 1970. In the second counterfactual scenario, we retain the official past evolution of health spending but assume that only out-of-pocket expenditure on health drive the increase in total health expenditures over time. The results obtained with these counterfactual scenarios reveal that less public health spending during the last decades would improve substantially French economic growth compared to baseline. Moreover, increasing the share of out-of-pocket expenditure on health in total health spending should allow to reduce the crowding-out effect and generate substantial productivity gains able to annihilate the negative effects of French population aging.

The rest of this Chapter is structured as follows. The model is outlined in Section 4.1. The calibration method and data are described in Section 4.2. Section 4.3 presents the simulation results obtained in baseline. Section 4.4 assesses the impact of different scenarios on (i) French demography, (ii) main macroeconomic aggregates, (iii) social protection budget and (iv) intertemporal individual welfare. Section 4.5 summarizes results obtained with counterfactual scenarios. Section 4.6 concludes.

## 4.1 An AGEM-OLG model with heterogeneous agents

The AGEM-OLG model is characterized by its demographic bloc described in Section 4.1.1, its production sector outlined in Section 4.1.2, the agent's behaviors characterized in Sections 4.1.4, 4.1.5 and 4.1.6, the public sector depicted in Section 4.1.7 and the private health insurance sector described in Section 4.1.8

### 4.1.1 Demographics

The building of demographic block is undertaken to provide a faithful representation of age and educational attainment structure of French population. For that purpose, we assume that population is composed by four young cohorts ranging in age from 0-4 year-old (denoted as cohort 0) to 15-19 year-old (denoted as cohort 4) and by sixteen adult cohorts ranging in age from 20-24 year-old (denoted as cohort 5) to 95 years-old and over (denoted as cohort 20). It implies that one period of the model corresponds to 5 years and cohort $t$ is formed by individuals aged 0 at period $t$.

The skill level is the only source of heterogeneity within each cohort. Each individual is able to reach three skill levels which are low-skill, medium-skill, and high-skill. Low-skilled are composed by individuals having an educational level below *baccalauréat* (referred to below as BAC)[2]. Medium-skilled are formed by agents who obtain BAC and make at most two years higher education. High-skilled are composed by individuals who make more than two years higher education. We use the superscripts $S = L, M, H$ to indicate the skill level of respectively low-skill, medium-skill, and high-skill. It follows that population aged $j$ ($j = 0, ..., 20$) with skill $S$ ($S = L, M, H$) at time $t$ is indicated by $P^S_{j,t}$. Decisions on educational level are taken during youth time. We assume that these decisions are determined exogenously for each skill and we indicate by $\pi^L_t$, $\pi^M_t$ and $\pi^H_t$ the proportions of young individuals in population opting for respecively low, medium, and high education.

Survival rates at each age also vary across skills. These latter are denoted by $\beta^S_{j,t}$ ($j = 1, ..., 20$) and determined by proportion of individuals with skill $S$ surviving between age $j-1$ and age $j$. Thus, the size of each cohort aged 0 to 20 is given by:

$$P^S_{j,t} = \beta^S_{j,t}(1 - \xi^S_{j,t})P^S_{j-1,t-1} \qquad j = 0, ..., 20 \tag{4.1}$$

for $S = L, M, H$ with $\xi^S_{j,t}$ the net emigration rates of cohorts $j$ with skill $S$ at time $t$.

### 4.1.2 Technology

The production sector is designed to exhibit the effect of health status on labor productivity. For that purpose, the production sector is characterized by a representative

[2]Baccalauréat is the French equivalent to Higher Leaving Certificate.

firm using labor in efficient units ($Q_t$) and physical capital ($K_t$) to produce a composite good ($Y_t$). Its technology is defined by a Cobb-Douglas production function with constant returns to scale:

$$Y_t = A_t K_t^{1-\varphi} Q_t^{\varphi} \tag{4.2}$$

where $\varphi$ provides the share of labor income in national output and $A_t$ denotes an exogenous process determining the total factor productivity.

Following the mincerian literature on wage determination (Ben-Porath (1967), Card and Lemieux (2001), and Wasmer (2001a)), the amount of labor in efficient units ($Q_t$) aggregates explicitly all attributes of workers. For that purpose, rather than considering the existence of multiple labor markets (for low, medium, and high skilled, for young and old workers), we assume that workers belonging to different cohorts and skill groups supply different combinations of schooling and experience. It implies that the number of competing factors is independent of the number of groups considered[3].

The quantity of labor in efficiency unit ($Q_t$) combines the state of health ($H_t$), the manpower ($L_t$), experience ($E_t$), and skill ($S_t$) according to a CES nested transformation function:

$$Q_t = H_t^{\Psi} \left[ L_t^{\rho} + \mu E_t^{\rho} + \Theta S_t^{\rho} \right]^{\frac{1}{\rho}} \tag{4.3}$$

The parameter $\rho$ represents the inverse of the elasticity of substitution among these attributes. $\mu$ is a fixed parameter indicating the firm's preference for experience. $\Theta_t$ designates an exogenous skill-biased technical progress. $\Psi$ is the parameter capturing the effect of $H_t$ on $Y_t$.

The representative firm behaves competitively on factor markets and maximizes its profit $PROF_t$ such that[4]:

$$PROF_t = Y_t - (r_t + d)K_t - w_t^L L_t - w_t^H S_t - w_t^E E_t \tag{4.4}$$

[3]This approach differs from the one of Card and Lemieux (2001), which aggregates age-specific levels of human capital in a CES function. The number of nested CES functions does not then depend on number of cohorts considered in our approach.

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

$d$ designates the depreciation rate of physical capital stock; $r_t$ indicates the interest rate[5]; and $w_t^L$, $w_t^H$ and $w_t^E$ represent the marginal productivity of respectively man-power, education, and experience. The conditions for profit maximization then provide the following relations:

$$r_t = (1-\varphi)A_t K_t^{-\varphi} Q_t^{\varphi} - d \tag{4.5}$$

$$w_t^L = \varphi A_t K_t^{1-\varphi} H_t^{\Psi\varphi} \left[L_t^{\rho} + \mu E_t^{\rho} + \Theta S_t^{\rho}\right]^{\frac{\varphi}{\rho}-1} \times L_t^{\rho-1} \tag{4.6}$$

$$w_t^E = \varphi A_t K_t^{1-\varphi} H_t^{\Psi\varphi} \left[L_t^{\rho} + \mu E_t^{\rho} + \Theta S_t^{\rho}\right]^{\frac{\varphi}{\rho}-1} \times \mu E_t^{\rho-1} \tag{4.7}$$

$$w_t^H = \varphi A_t K_t^{1-\varphi} H_t^{\Psi\varphi} \left[L_t^{\rho} + \mu E_t^{\rho} + \Theta S_t^{\rho}\right]^{\frac{\varphi}{\rho}-1} \times \Theta S_t^{\rho-1} \tag{4.8}$$

It appears that to maximize its profit, the firm remunerates each input at its marginal productivity. Moreover, equations (4.6), (4.7) and (4.8) underline that health status affects the rates of returns of all factors. Furthermore, the supplies in experience and education clearly influence the rates of returns of these two factors.

## 4.1.3 Preferences

### 4.1.3.1 The intertemporal utility function

As we consider the probability that each individual dies at the end of each period, each individual life expectancy is uncertain. It implies that the intertemporal well-being is characterized by an expected life-cycle utility function denoted by $E(U_t^S)$. This expected life-cycle utility function allows to exhibit all of health status effects on well-being. Indeed, individuals maximize an expected life-cycle utility function depending on its consumption expenditures and health status. Based on Hall and Jones (2007), we specify then $E(U_t^S)$ as follows:

$$E(U_t^S) = \sum_{j=0}^{20} \Delta_{j,t+j} \Upsilon_{j,t+j}^S u\left(c_{j,t+j}^S, h_{j,t+j}^S\right) \tag{4.9}$$

[5]Considering that domestic investment is financed by domestic savings, we neglect the possibility that an asynchronous aging between the major industrialized nations could affect capital flows. Thus, we retain here the assumption of a closed economy where the interest rate varies to clear the national financial market.

$c^S_{X,j,t+j}$ and $h^S_{j,t+j}$ designate respectively consumption and health status of individual with skill $S$ belonging to generation $t$ at age $j$ such that:

$$u(c^S_{j,t+j}, h^S_{j,t+j}) = b + \frac{\left(c^S_{j,t+j}\right)^{1-\eta}}{1-\eta} + \alpha \frac{\left(h^S_{j,t+j}\right)^{1-\sigma}}{1-\sigma} \tag{4.10}$$

As in Hall and Jones (2007), parameter $b$ allows to obtain a positive flow utility even with a negative value of $c^S_{j,t+j}$. $-1/\eta$ describes the constant intertemporal elasticity of substitution for consumption. The parameter $\alpha$ indicates the relative share of life quality in utility function such that $-1/\sigma$ provides the constant intertemporal elasticity of substitution for $h^S_{j,t+j}$. The term $\Delta_{j,t+j} = \prod_{s=1}^{j} \beta^S_{j,t}$ $(j = 1, ..., 20)$ in equation (4.9) indicates the cumulative probability of being alive at age $j$ (evaluated with respect to age 0) such that $\Delta_{0,t+0} = 1$. Finally, $\Upsilon^S_{j,t+j}$ designates the psychological discount factor applied on the instantaneous utility at each period. The characterization of $\Upsilon^S_{j,t+j}$ in this model involves that the psychological discount factor varies with age and skill-level and does not remain constant over time. We are then able to capture accurately the evolution of each individual well-being over time through equation (4.9).

Note that equation (4.9) highlights the two main effects of health state on well-being. The first effect occurs through the mortality rates channel. Indeed, following Hall and Jones (2007), we establish the relationship between $h^S_{j,t+j}$ and $\beta^S_{j,t}$ as follows:

$$h^S_{j,t} = \frac{1}{1-\beta^S_{j,t}} \tag{4.11}$$

Combining equation (4.11) and (4.9) reveals that having a good health allows to benefit more additional periods of utility by extending the lifetime. The second effect of health on well-being occurs through the positive effect of $h^S_{j,t+j}$ on the instantaneous utility as described in equation (4.9).

#### 4.1.3.2 The state of health

In the same line with Hall and Jones (2007), we define $h^S_{j,t+j}$ as follows:

$$h^S_{j,t} = \chi^S_{j,t} \left( \Omega^S_{j,t} \times \sum_{X=P,M,O} m^S_{X,j,t} \right)^{\kappa_j} \tag{4.12}$$

$\chi^S_{j,t}$ represents a scale parameter depending on age and skill level. $\kappa_j$, which varies with age, provides the technology of health production function. $\Omega^S_{j,t}$ describes an exogenous variable capturing all other individual inputs affecting health like pollution and sanitary environment. $m^S_{j,t}$ indicates the amount allocated to health spending such that three various types of health spending are considered:

- Health spending reimbursed by Social Security ($m^S_{P,j,t}$);
- Health spending reimbursed by Private Insurance ($m^S_{M,j,t}$);
- Out-of-pocket expenditure on health ($m^S_{O,j,t}$).

All variables affecting individual health status are thus taking into account through equation (4.12).

#### 4.1.3.3 The budget constraint

The uncertain life expectancy constrains each individual to insure himself against uncertainty at the beginning of his/her life. This insurance is provided by a market for each contingent consumption in the spirit of Arrow-Debreu. It implies that agents born at time $t$ must select their optimal plan for contingent consumption that maximizes the expected utility under their budget constraint[6].

The budget constraint requires equality between the expected value of expenditures

[6]Mortality is the only source of uncertainty. As mortality rates vary by age and educational level, prices and wages only depend on these characteristics.

and revenues, namely:

$$\sum_{j=0}^{13} R_{j,t+j}\Delta_{j,t+j}\left[\left(m^S_{O,j,t+j}+c^S_{j,t+j}\right)(1+\tau^c_{t+j})-T^S_{j,t+j}+\Gamma_t-m^S_{M,j,t+j}\right] = \left[\omega^L_{j,t+j}+\omega^E_{j,t+j}e^S_{j,t+j}+\omega^H_{j,t+j}s^S_{j,t+j}\right]\ell^S_{j,t+j} \tag{4.13}$$

$\tau^c_{t+j}$ indicates the tax rate on consumption and out-of-pocket expenditure on health in period $t+j$. $T^S_{j,t+j}$ denotes the amount of social transfers (retirement, unemployment, housing, family, social assistance and health spending reimbursed by public health insurance) perceived at age $j$. $\Gamma_t$ represents the flat tax levied by private health insurance to finance the health spending reimbursed by this institution. $m^S_{M,j,t+j}$ provides the amount received at age $j$ from this private insurance. $\ell^S_{j,t+j}$ measures labor supply at age $j$; $e^S_{j,t+j}$ and $s^S_{j,t+j}$ designate education and experience stock at period $t+j$. $\omega^L_{j,t+j}$, $\omega^H_{j,t+j}$ and $\omega^E_{j,t+j}$ represent respectively the contingent net wages after taxes related to manpower, education, and experience.

Let $r_t$ the interest rate between periods $t$ and $t+1$. It involves that the discount factor applied on income and expenditures is written as follows:

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

such that $R_{0,t}=1$ by convention. Thus, by maximizing the expected utility (equation 4.9) under the budget constraint (equation 4.13), we obtain the law of consumption evolution throughout the consumer's life, namely:

$$c^S_{j+1,t+j+1} = \left[\frac{\Upsilon^S_{j,t+j}\times\beta^S_{j,t}\times(1+\tau^c_t)\times(1+r_{t+1})}{(1+\tau^c_{t+1})}\right]^\eta \times c^S_{j,t+j} \qquad \forall S;\forall j=1,...,20 \tag{4.14}$$

The difference between income and consumption provides the individual implicit asset holdings $a^S_{j,t+j}$, namely:

$$\begin{aligned} R_{j,t+j}\Delta_{j,t+j}a_{j,t+j} = {} & R_{j,t+j}\Delta_{j,t+j}a^S_{j-1,t+j-1} + b^S_{j,t+j} \\ & \left(\omega^L_{j,t+j} + \omega^E_{j,t+j}e^S_{j,t+j} + \omega^H_{j,t+j}s^S_{j,t+S}\right)\ell^S_{j,t+j} \\ & - \left[\left(m^S_{O,j,t+j} + c^S_{j,t+j}\right)(1+\tau^c_{t+j}) - T^S_{j,t+j} + \Gamma_t - m^S_{M,j,t+j}\right] \end{aligned} \tag{4.15}$$

such that

$$\begin{aligned} a^S_{0,t} = {} & \left(\omega^L_{0,t} + \omega^E_{0,t}e^S_{0,t} + \omega^H_{0,t}s^S_{0,t}\right)\ell^S_{0,t} + b^S_{0,t} \\ & - \left[\left(m^S_{O,0,t} + c^S_{0,t}\right)(1+\tau^c_t) - T^S_{0,t} + \Gamma_t - m^S_{M,0,t}\right] \end{aligned}$$

In equation (4.15), $b^S_{j,t+j}$ designates the bequest perceived by individuals belonging to generation $j$ with skill $S$ at period $t+j$. The bequest comes from died individuals at each period. We assume that the bequest process follows an equal redistribution between all survival individuals. Thus, through this bequest allocation, the physical capital market clears as the saving of died people is redistributed to survival one and allow them to increase their budget.

### 4.1.4 Educational decisions

The educational attainment of each agent depends on time required to obtain a degree. Between 15 and 24 years-old, the proportion of time allocated to education and necessary to reach the skill $S$ is given by the exogenous variable $\overline{u}_S \in [0;1]$ such that $\overline{u}_L < \overline{u}_M < \overline{u}_H$. The educational decision is purely exogenous in the model to perfectly reproduce the skill structure of French population over time.

### 4.1.5 Wage and unemployment

Unemployment is also exogenous in the model. More precisely, let $\bar{\Phi}^L_t$ and $\bar{\Phi}^{MH}_t$ the exogenous average unemployment rates associated with respectively unskilled and skilled workers such that:

$$\bar{\Phi}_t^L = \left(aj\_cho_t^L \sum_{j=5}^{13} P_{j,t}^L q_{j,t}^L \Phi_{j,t}^L\right) / \left(\sum_{j=5}^{13} P_{j,t}^L q_{j,t}^L\right)$$

$$\bar{\Phi}_t^{MH} = \left(aj\_cho_t^{MH} \sum_{j=5}^{13} P_{j,t}^M q_{j,t}^M \Phi_{j,t}^M + P_{j,t}^H q_{j,t}^H \theta_{j,t}^H\right) / \left(\sum_{j=5}^{13} P_{j,t}^M q_{j,t}^H + P_{j,t}^H q_j^H\right)$$

$aj\_cho_t^L$ and $aj\_cho_t^{MH}$ designate the adjustment variables allowing to reproduce the historical evolution of unemployment rates. In other words, $aj\_cho_t^L$ and $aj\_cho_t^{MH}$ ensure the convergence of actual unemployment rate to its long-term rate, namely 4.5% in average in 2060 (Conseil d'Orientation des Retraites 2015). $q_{j,t}^S$ informs on the exogenous participation rate of workers aged $j$ with skill $S$ at period $t$. $\Phi_j^S$ indicates the exogenous age- and skill-specific unemployment rates. Note that this latter remains constant over time.

These exogenous average unemployment rates imply that levels of real wages at the aggregate level are determining for a given unemployment rate for unskilled and skilled workers. In other words, (i) labor market clears for a given $\bar{\Phi}_t^L$ and $\bar{\Phi}_t^{MH}$ and (ii) levels of real wages cannot adjust to diminish the unemployment rate. A long-term structural unemployment then occurs in French economy and real wages are not able to remove this structural unemployment.

### 4.1.6 Labor supply, health, education, and experience

The pattern of manpower supply, education, and experience depends on time devoted to education. Indeed, the vector of manpower supply from an agent of generation $t$ is written as:

$$\ell_t^S = \begin{pmatrix} q_t^S(1-\overline{u}_S),\ q_{t+1}^S,\ q_{t+2}^S,\ q_{t+3}^S, q_{t+4}^S, q_{t+5}^S, q_{t+6}^S, \\ q_{t+7}^S, q_{t+8}^S, q_{t+9}^S, q_{t+10}^S, q_{t+11}^S, q_{t+12}^S, \\ q_{t+13}^S(1-\alpha_{t+13}), 0, 0, 0, 0, 0, 0, 0 \end{pmatrix} \qquad (4.16)$$

$q_t$ indicates the exogenous participation rate at period $t$. This variable allows to consider the rise in women participation rate over time. Moreover, in equation (4.16),

$\alpha_{t+13}$ informs on the exogenous participation rates during the thirteenth period of life (between ages 60 and 65).

Following Wasmer (2001b), individual experience, $e_t^S$, is given by the aggregate of past employment experiences such that:

$$e_t^S = \begin{pmatrix} 0, \\ (1-\overline{u}_S)q_t\theta_e^1, \\ (1-\overline{u}_S)q_t\theta_e^2 + q_{t+1}\theta_e^1, \\ (1-\overline{u}_S)q_t\theta_e^3 + q_{t+1}\theta_e^2 + q_{t+2}\theta_e^1, \\ (1-\overline{u}_S)q_t\theta_e^4 + q_{t+1}\theta_e^3 + q_{t+2}\theta_e^2 + q_{t+3}\theta_e^1, \\ ,..., \\ (1-\overline{u}_S)q_t\theta_e^{13} + ... + q_{t+12}\theta_e^1, \\ 0,0,0,0,0,0,0 \end{pmatrix} \tag{4.17}$$

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

In the same line with Chojnicki, Docquier, and Ragot (2011), the proportion of time devoted to education during the first period of life, $\overline{u}_S$, is transformed in units of effective labor through the following production function of human capital $\epsilon\overline{u}_S^\psi$. The specification of this educational technology is then driven by $\epsilon > 0$ and $\psi \in (0,1)$. It follows that the vector of skill supply is written as:

$$s_t^S = \begin{pmatrix} 0,\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi, \\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi,\ \epsilon\overline{u}_S^\psi, \\ 0,0,0,0,0,0,0 \end{pmatrix} \tag{4.18}$$

Finally, we assume that each component of labor supply is weighted by health state of each individual to obtain an efficient labor supply. The vector of health is then given by:

$$h_t^S = \begin{pmatrix} h_t^S,\ h_{t+1}^S,\ h_{t+2}^S,\ h_{t+3}^S, h_{t+4}^S, h_{t+5}^S, \\ h_{t+6}^S, h_{t+7}^S, h_{t+8}^S, h_{t+9}^S, h_{t+10}^S, h_{t+11}^S, \\ h_{t+12}^S,\ h_{t+13}^S,\ h_{t+14}^S,\ h_{t+15}^S,\ h_{t+16}^S, \\ h_{t+17}^S, h_{t+18}^S, h_{t+19}^S, h_{t+20}^S \end{pmatrix}$$

such that health production is defined by equation (4.12). Thus, the aggregate quantities of health ($H_t$), manpower ($L_t$), experience ($E_t$), and education ($S_t$) are indicated by:

$$H_t = \sum_{j=5}^{13} \sum_{S=L,M,H} P_{j,t}^S h_{j,t}^S \tag{4.19}$$

$$L_t = \sum_{j=5}^{13} \sum_{S=L,M,H} P_{j,t}^S \ell_{j,t}^S \tag{4.20}$$

$$E_t = \sum_{j=5}^{13} \sum_{S=L,M,H} P_{j,t}^S \ell_{j,t}^S e_{j,t}^S \tag{4.21}$$

$$S_t = \sum_{j=5}^{13} \sum_{S=L,M,H} P_{j,t}^S \ell_{j,t}^S s_{j,t}^S \tag{4.22}$$

### 4.1.7 The public sector

#### 4.1.7.1 The public transfers

Subsidies to education, pensions, health spending, unemployment benefits, housing costs, family allowances, and social assistance spendings compose the vector of public transfers, $\overline{T}_t^S$, such that:

$$\overline{T}_t^S = \begin{pmatrix} v_t q_t \overline{u}_S \omega_{5,t}^L + \gamma_{san,5}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,5}^S g_t^{cho} \Phi_5^S aj\_cho_t^S + \gamma_{\log,5}^S g_t^{\log} + \gamma_{caf,5}^S g_t^{fam} \\ +\gamma_{rmi,5}^S g_t^{rmi}, \\ \gamma_{san,6}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,6}^S g_t^{cho} \Phi_6^S aj\_cho_t^S + \gamma_{\log,6}^S g_t^{\log} + \gamma_{caf,6}^S g_t^{fam} + \gamma_{rmi,6}^S g_t^{rmi}, \\ \gamma_{san,7}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,7}^S g_t^{cho} \Phi_7^S aj\_cho_t^S + \gamma_{\log,7}^S g_t^{\log} + \gamma_{caf,7}^S g_t^{fam} + \gamma_{rmi,7}^S g_t^{rmi}, \\ \gamma_{san,8}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,8}^S g_t^{cho} \Phi_8^S aj\_cho_t^S + \gamma_{\log,8}^S g_t^{\log} + \gamma_{caf,8}^S g_t^{fam} + \gamma_{rmi,8}^S g_t^{rmi}, \\ \gamma_{san,9}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,9}^S g_t^{cho} \Phi_9^S aj\_cho_t^S + \gamma_{\log,9}^S g_t^{\log} + \gamma_{caf,9}^S g_t^{fam} + \gamma_{rmi,9}^S g_t^{rmi}, \\ \gamma_{san,10}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,10}^S g_t^{cho} \Phi_{10}^S aj\_cho_t^S + \gamma_{\log,10}^S g_t^{\log} + \gamma_{caf,10}^S g_t^{fam} + \gamma_{rmi,10}^S g_t^{rmi}, \\ \gamma_{san,11}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,11}^S g_t^{cho} \Phi_{11}^S aj\_cho_t^S + \gamma_{\log,11}^S g_t^{\log} + \gamma_{caf,11}^S g_t^{fam} + \gamma_{rmi,11}^S g_t^{rmi}, \\ \gamma_{san,12}^S g_t^{san} \Delta_t^{PIB} + \gamma_{cho,12}^S g_t^{cho} \Phi_8^S aj\_cho_t^S + \gamma_{\log,12}^S g_t^{\log} + \gamma_{caf,12}^S g_t^{fam} + \gamma_{rmi,12}^S g_t^{rmi}, \\ \alpha_{t+13} \gamma_{ret,13,t+13}^S + \gamma_{san,13}^S g_t^{san} \Delta_t^{PIB} + (1-\alpha_{t+13}) \gamma_{cho,13}^S g_t^{cho} \Phi_{13}^S aj\_cho_t^S \\ +\gamma_{\log,13}^S g_t^{\log} + \gamma_{caf,13}^S g_t^{fam} + \gamma_{rmi,13}^S g_t^{rmi}, \\ \gamma_{ret,14,t+14}^S + \gamma_{san,14}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,14}^S g_t^{\log} + \gamma_{caf,14}^S g_t^{fam} + \gamma_{rmi,14}^S g_t^{rmi}, \\ \gamma_{ret,15,t+15}^S + \gamma_{san,15}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,15}^S g_t^{\log} + \gamma_{caf,15}^S g_t^{fam} + \gamma_{rmi,15}^S g_t^{rmi}, \\ \gamma_{ret,16,t+16}^S + \gamma_{san,16}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,16}^S g_t^{\log} + \gamma_{caf,16}^S g_t^{fam} + \gamma_{rmi,16}^S g_t^{rmi}, \\ \gamma_{ret,17,t+17}^S + \gamma_{san,17}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,17}^S g_t^{\log} + \gamma_{caf,17}^S g_t^{fam} + \gamma_{rmi,17}^S g_t^{rmi}, \\ \gamma_{ret,18,t+18}^S + \gamma_{san,18}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,18}^S g_t^{\log} + \gamma_{caf,18}^S g_t^{fam} + \gamma_{rmi,18}^S g_t^{rmi}, \\ \gamma_{ret,19,t+19}^S + \gamma_{san,19}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,19}^S g_t^{\log} + \gamma_{caf,19}^S g_t^{fam} + \gamma_{rmi,19}^S g_t^{rmi}, \\ \gamma_{ret,20,t+20}^S + \gamma_{san,20}^S g_t^{san} \Delta_t^{PIB} + \gamma_{\log,20}^S g_t^{\log} + \gamma_{caf,20}^S g_t^{fam} + \gamma_{rmi,20}^S g_t^{rmi} \end{pmatrix} \tag{4.23}$$

$\gamma_{risk,j}^S g_t^{risk}$ indicates the age- and skill-specific total transfers allocated by government to agents aged $j$ with skill $S$ for retirement ($ret$), unemployment ($cho$), housing ($log$), family ($fam$), social assistance ($rmi$) and public health spending ($san$) such that $\gamma_{san,j}^S g_t^{san} = m_{P,j,t}^S$. The variable $\gamma_{risk,j}^S$ provides the social aid profile by age and education, and $g_t^{risk}$ designates the scale variable capturing the generosity of welfare programs.

All $\gamma_{risk,j}^S$ are assimilated to exogenous variables varying with social risk, age and education except $\gamma_{ret,j,t+j}^S$. We consider $\gamma_{ret,X,j,t+j}^S$ as an endogenous variable measuring the pension benefits allocated to each retired individual belonging to generation $t$ in period $t+j$ ($j = 13$ to $20$). For that purpose, based on current pension legislation, the pension benefits are calculated as a proportion of the average wage perceived during the last twenty-five years of work[7], namely:

$$\gamma^{S}_{ret,j,t+j} = \eta_t \times \frac{1}{5}\sum_{j=8}^{12}\left[\omega^{L}_{j,t+j} + \omega^{E}_{j,t+j}e^{S}_{j,t+j} + \omega^{H}_{j,t+j}h^{S}_{j,t+j}\right] \qquad (j = 8, ..., 12)$$

In this formula, $\eta_t$ denotes the replacement rate measuring the generosity of pension system. Note that, to replicate French pension system, pension benefits are implicitly indexed to price.

$\gamma^{S}_{san,t} g^{san}_t \Delta^{PIB}_t$ allows to reproduce the evolution of public health expenditures over time by considering the size and structure of French population, and the GDP growth rate ($\Delta^{PIB}_t$). We take into account the effect of GDP growth rate on the evolution of health spending as suggested by Mahieu (2000) and Azizi and Pereira (2005). Following these authors, we assume an unit price elasticity on health expenditures, namely, an increase of 1% of GDP, *ceteris paribus*, implies a 1% increase in health spending. Obviously, we consider the effects of other factors like change in age and skills structure of French population on the evolution of health expenditures.

$\gamma^{S}_{cho,t}$ provides an individual profile of unemployment benefits. This profile is weighted by $\Phi^{S}_{j} aj\_cho^{S}_{t}$ informing on unemployment rates by age and skill-level. Thus, by calculating $\gamma^{S}_{cho,t} g^{cho}_t \Phi^{S}_{j} aj\_cho^{S}_{t}$ for each age and each skill, we are able to reproduce the evolution of unemployment expenditures in France over time.

All other social expenditure profiles (housing, family, and social assistance) are also determined for each skill and age and are scaled uniformly to reproduce the evolution of their aggregate amount in French economy.

#### 4.1.7.2 The public revenue

To finance the public transfers and other non-age specific public consumption, the government issues bonds and levies taxes on labor income ($\tau^{w}_t$), consumption and out-of-pocket expenditures on health ($\tau^{c}_t$), and capital income ($\tau^{k}_t$). Moreover, some specific social security contributions such that social contributions ($\text{cot}_t$), based on

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

labor income, and General Social Contribution ($csg_t$), based on both labor and capital income and retirement and unemployment transfers, also allow to finance social transfers. Social transfers belong to the four major public expenditure which are education subsidies, social transfers (pensions, health, unemployment, housing, family, and welfare), non-age specific government consumption, and interest on public debt. We deduce the following government budget constraint:

$$(\tau_t^w + \cot_t + csg_t)(w_t^L L_t + w_t^E E_t + w_t^H H_t) + \tau_t^c (C_t + M_{O,t}) + (\tau_t^k + csg_t) r_t K_t + D_{t+1}$$
$$= \sum_j \sum_S P_{j,t}^S \overline{T}_{j,t}^S + \vartheta_t Y_t + (1 + r_t) D_t$$

$D_t$ indicates the public debt at the beginning of period $t$. $\vartheta_t$ designates the share in GDP of non-individualized government consumption. $\overline{T}_{j,t}^S$ provides the total amount of transfers perceived by each age and skill level. $C_t$ and $M_{O,t}$ describe respectively the aggregate consumption expenditures and the aggregate out-of-pocket expenditure on health. To balance this government intertemporal budget constraint, we assume that the path of debt/GDP ratio is given and the tax on wages ($\tau_t^w$) varies endogenously to ensure the balance of the budget.

Let $T_t^{risk}$ the total transfers allocated at period $t$ such that:

$$T_t^{ret} = \sum_j \sum_S P_{j,t}^S \alpha_{t+j} \gamma_{ret,j,t+j}^S$$
$$T_t^{san} = \sum_j \sum_S P_{j,t}^S \gamma_{san,j}^S g_t^{san} \Delta_t^{PIB}$$
$$T_t^{cho} = \sum_j \sum_S P_{j,t}^S \gamma_{cho,j}^S g_t^{cho} \Phi_{j,t}^S aj\_cho_t^S$$
$$T_t^{caf} = \sum_j \sum_S P_{j,t}^S (\gamma_{\log,j}^S g_t^{\log} + \gamma_{fam,j}^S g_t^{fam})$$
$$T_t^{rmi} = \sum_j \sum_S P_{j,t}^S \gamma_{rmi,j}^S g_t^{rmi}$$

For each risk corresponds a special fund autonomously financed except for social assistance. Social assistance fund does not perceive any specific funding as government finances directly this fund through its budget. The funds for retirement, health expenditures, unemployment, family benefits and housing are financed by three sources: (i) social contributions (based on labor income), (ii) earmarked taxes (mainly formed by $csg$, and calculated on labor and capital income and retirement and unemployment transfers), and (iii) public contributions. Thus, for each fund, the following equality occurs:

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

$\cot_t^{risk}$ and $csg_t^{risk}$ denote respectively the social contribution rates and taxes earmarked for each social risk. $cpub_t^{risk}$ represents the public contribution allocated by government to each fund. This contribution is expressed as a proportion of social contributions. We do not impose any balanced budget rule for each fund. Thus, $Solde_t^{risk}$ varies with all demographic and economic changes even if the public debt/GDP ratio is fixed and the tax on wages ($\tau_t^w$) allows to balance the government inter-temporal budget constraints.

### 4.1.8 The private health sector

The private health sector reimburses a part of private health spending made by each agent. For that purpose, this private institution defines a repayment profile, given by $\zeta_{j,t}^S$, varying with age and skill-level. The private health sector determines also the generosity of health insurance by adjusting the scale variable $x_t$. It implies that $\zeta_{j,t}^S \times x_t$ provides the age and skill specific health spending reimbursed by the private health insurance to agents aged $j$ with skill-level $S$ such that $\zeta_{j,t}^S \times x_t = m_{M,j,t}^S$. Moreover, as for public health spending, we take into account the effect of GDP growth ($\Delta_t^{PIB}$) on the evolution of health spending reimbursed by private health insurance. Then, we also apply an unit price elasticity on private health expenditures. Thus, the vector of health reimbursement is given by $\Xi_t^S$ such that:

$$\Xi_t^S = \begin{pmatrix} \zeta_{5,t}^S, \zeta_{6,t}^S, \zeta_{7,t}^S, \zeta_{8,t}^S, \zeta_{9,t}^S, \zeta_{10,t}^S, \zeta_{11,t}^S, \zeta_{12,t}^S \\ \zeta_{13,t}^S, \zeta_{14,t}^S, \zeta_{15,t}^S, \zeta_{16,t}^S, \zeta_{17,t}^S, \zeta_{18,t}^S, \zeta_{19,t}^S, \zeta_{20,t}^S \end{pmatrix} \times x_t \times \Delta_t^{PIB} \qquad (4.24)$$

The total amount of health spending reimbursed by the private health insurance is provided by $\bar{\Xi}_t$ with:

$$\bar{\Xi}_t = \sum_j \sum_S P^S_{j,t} \times \zeta^S_{j,t} \times x_t \times \Delta^{PIB}_t$$

To finance these private health reimbursements, health insurance levies flat tax $\Gamma_t$ on all agents' income as indicated in agent's budget constraint (see equation 4.13). The private health insurance adjusts at each period $\Gamma_t$ to obtain a balanced budget.

The part of private health spending non-reimbursed by health insurance corresponds to out-of-pocket expenditure on health ($m^S_{O,j,t}$). Based on the evolution of health spending reimbursed by private and public health insurances over time, $m^S_{O,j,t}$ is deduced as a residual allowing to replicate the evolution of total health spending in France.

## 4.2 Baseline calibration

The value of most exogenous variables composing this model can be deduced by exploiting data from specific economic surveys. The value of most parameters can be fixed by referring to empirical estimation established in well-known studies. At last, the numerical value given to unobserved exogenous variables can be obtained by undertaking a dynamical calibration process. This section aims to describe the calibration methodology to determine the numerical value of exogenous variables in this model.

### 4.2.1 Demographic data

In the baseline scenario, the demographic block is calibrated to reproduce the available socio-demographic data. For that purpose, before 1970, we exploit the historical data on age distribution of French population provided by Vallin and Meslé (2001). Between 1970 and 2005, the age and skill structures are obtained by using data from French population censuses of 1968, 1982, 1990, 1999, 2005 and 2010. French population censuses then allow to determine the proportion of low-, medium-, and highly-skilled among young people ($\pi_t^L$, $\pi_t^M$ and $\pi_t^H$).

To perform our population forecasts until 2060, we retain the assumptions used by Blanpain and Chardon (2010) in their latest central scenario population projections. After 2060, we maintain mortality rates, fertility rates, and net emigration rates at their 2060 levels and extend population forecasts until 2250 for the model purposes.

Data on death rates by age and educational level ($\beta_{j,t}^S$) are calculated by exploiting life tables by age provided by Vallin and Meslé (2001), for the period 1900-2010, and INSEE population forecasts (Blanpain and Chardon 2010), for the period 2010-2060. To disaggregate these mortality rates by educational level, we apply the Standardized Mortality Rates (SMR) estimated by Mejer (2004) for each educational level and each age. These demographic data allow thereafter to deduce accurately the net emigration rates ($\xi_{j,t}^S$) until 2250.

### 4.2.2 Parameters

As usual, the share in GDP of labor income, namely $\varphi$, is set at 0.7. The numerical value of parameter $\rho$ is also equal to 0.7. This value implies that the elasticity of substitution between manpower, education, and experience is equal to 3.33 as this elasticity is given by $1/(1-\rho)$. This number corresponds to the usual value of elasticity of substitution between skilled and unskilled workers used in conventional production functions (De La Croix and Docquier 2007). Finally, we exploit the value retained by Chojnicki and Ragot (2015) on firm's preference for experience, namely $\mu$ is equal to 0.5. Moreover, following the median hypothesis of Wasmer (2001b), the non-age specific annual depreciation rate of experience is set at 3%. It means that $\theta_e^1 = 0,737$, $\theta_e^2 = (\theta_e^1)^2$, and so on. The value of $\Psi$ is set at 0.02857. $\Psi = 0.02857$ allows to assume that $\Psi \times \varphi$ is equal to 0.02 corresponding to elasticity of GDP with respect to health improvement estimated by Aghion, Howitt, and Murtin (2011).

The value of parameters determining educational capital production function are chosen to reproduce the historical evolution of wage profile in France. For that purpose, we assume that $\psi$ is equal to 0.75. By assuming that the concavity of relationship between income and educational level is set at 0.75, we replicate accurately the income differences among low-, medium-, and highly-skilled workers. Moreover, the scale parameter $\epsilon$, in this production function, is set at 1.2 to obtain likely wage profile.

The only exogenous parameter defining health state production function is $\kappa_j$. Based on empirical estimation obtained by Hall & Jones (2007), we retain that the elasticity of health status with respect to health inputs has the following values:

- $\kappa_5 = \kappa_6 = 0.155$
- $\kappa_7 = \kappa_8 = 0.2$
- $\kappa_9 = \kappa_{10} = 0.24$
- $\kappa_{11} = \kappa_{12} = 0.245$
- $\kappa_{13} = \kappa_{13} = 0.17$
- $\kappa_{15} = \kappa_{14} = 0.13$
- $\kappa_{17} = \kappa_{15} = 0.105$
- $\kappa_{19} = \kappa_{20} = 0.04$

Following Hall & Jones (2007), we assume then that the elasticity of health status with respect to health inputs decreases with age. In other words, according to these values, returns to health spending as health improvement decline with age.

To finish, as usual, the depreciation rate of capital ($d$) is set at 0.4. This value implies an annual depreciation rate of 5%.

### 4.2.3 Observed exogenous processes

Taxes on labor income ($\tau_t^w$), capital income ($\tau_t^k$), consumption and out-of-pocket expenditure on health ($\tau_t^c$) form the government revenue. To calibrate these taxes, we match the share in GDP of these different tax revenues in the model with their real share in GDP in French economy (INSEE 2014). Moreover, the evolutions of these taxes allow to replicate the historical evolution of the share in GDP of these taxes revenue as informed in French national accounts (INSEE 2014).

As described above, the share in GDP of public consumption expenditures is given by $\vartheta_t$. To provide the numerical value of $\vartheta_t$ between 1900 and 2010, we exploit the historical evolution of non-age specific public spendings estimated in OECD statistics. Since 2015, we maintain $\vartheta_t$ at its 2010 level. Age- and skill-specific public transfers, namely $\gamma^S_{risk,j}$, including health costs, unemployment, housing, family allowances, and social assistance spending, are corrected by the scale factor $g^{risk}_t$ until 2010. It implies that social transfers profiles are held constant during the calibration process and $g^{risk}_t$ varies to reproduce the evolution of the share in GDP of public transfers until 2010. Note that social transfers profiles used in this AGEM-OLG are similar to those exploited in our Generational Accounting model in Chapter 3.

$\gamma^S_{risk,j} g^{risk}_t$ allows to replicate the evolution of social transfers as reported in official statistics reports until 2010. Since 2015, the share in GDP of pensions and health expenditures follow the official forecasts provided respectively by Conseil d'Orientation des Retraites (2015) and HCAAM (2013). We apply the same methodology to estimate the repayment profiles $\zeta^S_{j,t}$ for private health spending and the scale parameter $x_t$ indicating the generosity of private health insurance. Note that forecasts on share in GDP of private health spending reimbursed by private insurance is deduced from HCAAM (2013). For the other social transfers, $g^{risk}_t$ is held constant after 2010, and the share in GDP of these social transfers is determined endogenously through the model. Finally, we exploit the study of De La Croix and Docquier (2007) to give a numerical value to the subsidy rate on tertiary education $v_t$.

Elderly participation rate also belongs to observed exogenous variables. Indeed, by using data on the effective age of retirement estimated by both Blondal and Scarpetta (1997) and COR, we are able to estimate the elderly participation rate, $\alpha_{t+13}$. Finally, the overall participation rates, $q_t$, are deduced from official statistics provided by INSEE.

### 4.2.4 Unobserved exogenous processes

Total factor productivity ($A_t$), the skill-biased technical progress ($\Theta_t$), the scale factor on pensions benefit ($\eta_t$), the scale factors on age-specific social transfers ($g_t^{risk}$), the psychological heterogenous discount factor ($\Upsilon_{j,t+j}^S$), the scale parameter of health production function ($\chi_{j,t}^S$) and all individual variables affecting health status ($\Omega_{j,t}^S$) are determined by applying a dynamical calibration process. Indeed, time-series data providing information on evolution of these exogenous variable are not available. To identify the evolution of these exogenous variables, we then apply the calibration method suggested by De La Croix and Docquier (2007). For that purpose, we begin by replicating properly French demographic and economic trends in the baseline scenario. Thereafter, we exploit this baseline scenario to identify the unobserved exogenous processes cited above. More precisely, we reproduce exactly through $A_t$, $\Theta_t$, $\eta_t$ and $g_t^{risk}$ the historical evolution of the following endogenous variables: the GDP growth rate, the wage gap between highly-skilled and low-skilled individuals aged 45, the share in GDP of pension expenditures, and the share in GDP of other social transfers. The historical growth rate of GDP stems from Maddison (2001) before 1950 and INSEE beyond this date, and is set at 20% per decade. The wage gaps at age 45 between highly-skilled and low-skilled workers comes from the Employment Surveys between 1960 and 2007.

Generally, the psychological discount factor is characterized by a constant non-age and non-skill specific exogenous parameter. However, in this model, we perform our simulation by assuming that the psychological discount factor is a non-constant exogenous variable varying with age and skill-level and does not remain constant over time. Unfortunately, time-series data on the evolution of $\Upsilon_{j,t+j}^S$ is not available. To offset this issue, we reproduce exactly through $\Upsilon_{j,t+j}^S$ the historical evolution of consumption expenditures for each age and each skill-level. Data on consumption by age and educational level are obtained by exploiting the different waves of Survey on French

Household Budget (referred in Chapter 3 as BdF).

To identify $\Omega^S_{j,t}$ and $\chi^S_{j,t}$, we begin by exploiting equation (4.11). Indeed, by combining equation (4.11) and data on mortality rates, we manage to calibrate properly the individual health status for each age and each skill-level. Thereafter, by rearranging the health status technology defined by equation (4.12), we deduce the following relationship:

$$g\_\Omega^S_{j,t} = \frac{\left(1 + g\_h^S_{j,t}\right)^{1/\kappa_j}}{1 + g\_m^S_{j,t}} - 1 \tag{4.25}$$

with $g\_\Omega^S_{j,t}$, $g\_h^S_{j,t}$ and $g\_m^S_{X,j,t}$ the growth rate of respectively $\Omega^S_{j,t}$, $h^S_{j,t}$ and $\sum\limits_{X=P,M,O} m^S_{X,j,t}$. As data on $h^S_{j,t}$ and $m^S_{X,j,t}$ are available during the calibration process, we are able to give the numerical value of $g\_h^S_{j,t}$ and $g\_m^S_{X,j,t}$. It implies that by exploiting the relationship defining the growth rate of $\Omega^S_{j,t}$, we deduce the exact value of $\Omega^S_{j,t}$ for each age and each skill. The vector of $\Omega^S_{j,t}$ is then defined as follow:

$$\Omega^S_j = \begin{pmatrix} 1, \left(1+g\_\Omega^S_{j,t+1}\right), \left(1+g\_\Omega^S_{j,t+1}\right) + \left(1+g\_\Omega^S_{j,t+2}\right), \\ \left(1+g\_\Omega^S_{j,t+1}\right) + \left(1+g\_\Omega^S_{j,t+2}\right) + \left(1+g\_\Omega^S_{j,t+3}\right), \\ ,..., \\ \left(1+g\_\Omega^S_{j,t+1}\right) + ... + \left(1+g\_\Omega^S_{j,t+12}\right) + \left(1+g\_\Omega^S_{j,t+13}\right), \\ ,..., \\ \left(1+g\_\Omega^S_{j,t+1}\right) + ... + \left(1+g\_\Omega^S_{j,t+19}\right) + \left(1+g\_\Omega^S_{j,t+20}\right), \\ ,..., \\ \left(1+g\_\Omega^S_{j,t+1}\right) + ... + \left(1+g\_\Omega^S_{j,t+344}\right) + \left(1+g\_\Omega^S_{j,t+345}\right) \end{pmatrix}$$

with $g\_\Omega^S_{j,0} = 0$ by convention. Thus, as we manage to set the numerical value of $h^S_{j,t}$, $m^S_{j,t}$, $\Omega^S_{j,t}$ and $\kappa_j$, we are able to determine easily $\chi^S_{j,t}$ through equation (4.12) as:

$$\chi^S_{j,t} = \frac{h^S_{j,t}}{(\Omega^S_{j,t} \times \sum\limits_{X=P,M,O} m^S_{j,t})^{\kappa_j}}$$

Basically, our calibration methodology involves swapping seven class of exogenous variables with seven class of endogenous variables as a preliminary identification step. This process looks like the recursive approach (backsolving) suggested by Sims (1990) for general stochastic equilibrium models. Following De La Croix and Docquier (2007) and Chojnicki and Ragot (2015), we adopt the same insight by considering the exogenous processes as endogenous. This method does not mean that we solve the model during the calibration process but implies that we undertake the calibration process in a deterministic framework. Thus, calibration occurs dynamically and provides much more accurate results than performing the calibration in a hypothetical steady-state as done in most AGE models and as suggested by Auerbach and Kotlikoff (1987).

## 4.3 The baseline scenario

### 4.3.1 French population in baseline

As mentioned in Section 4.1.1, the demographic bloc is driven by endogenous mortality rates depending on health status. In addition, as underlined in Section 4.2.1, in the baseline scenario, the demographic bloc is also calibrated to reproduce (i) the official statistics on socio-demographic data before 2015 and (ii) the central scenario of official population forecasts after 2015 (Blanpain and Chardon 2010). The central scenario of official demographic forecasts implies that after 2015 the fertility rate is equal to 1.95 children per woman and the annual net immigration flow is set at 100,000 individuals. Thus, by undertaking our population forecasts, we highlight the following French demographic features:

- In 2060, French population aged 20 and over should represent 57.1 million of persons (see Table 4.1). Between 2010 and 2060, French population aged 20 and over should then increase by more than 9 million persons. After 2060, this part of French population should continue to grow by reaching 59.8 million of persons in 2100.
- During the coming decades, this positive trend on French population evolution is not driven by the increase in working-age population. Indeed, between 2010 and 2040, the number of working-age people should decrease slightly from 36.9 million of persons in 2010 to 36.6 million of persons in 2040 (-0.7%). However, after 2040, the size of working-age population should begin to increase and reach

38.9 million of persons in 2100.

- Contrariwise to the size of working-age population, the size of population aged 65 and over should always continue to grow during the coming decades. Thus, in 2100, population aged 65 and over should represent 20.8 million against 10.5 million of persons in 2010.

- Between 2010 and 2040, the slight decrease in working age population combined with the increase in population aged 65 and over induces a sharp increase in OADR. The OADR is equal to 28.6% in 2010 and could reach 49.4% in 2040. After 2040, OADR continues to grow and should attain 53.5% in 2100. By referring on OADR's evolution, it seems that French population aging process accelerates between 2010 and 2040 and stabilizes after 2040.

Table 4.1: French population in baseline scenario (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***Total population (a)*** | | | | | | | | |
| (x1000) | 47 502 | 50 159 | 52 692 | 54 796 | 56 002 | 57 117 | 58 885 | 59 869 |
| ***Working-age population (b)*** | | | | | | | | |
| (x1000) | 36 937 | 36 727 | 36 675 | 36 675 | 37 220 | 37 677 | 38 415 | 38 985 |
| ***Population aged 65 and over*** | | | | | | | | |
| (x1000) | 10 565 | 13 432 | 16 017 | 18 121 | 18 783 | 19 440 | 20 469 | 20 884 |
| ***Old-age-dependency ratio (c )*** | | | | | | | | |
| (%) | 28.6% | 36.6% | 43.7% | 49.4% | 50.5% | 51.6% | 53.3% | 53.6% |

Source: authors' calculation
(a) Total population in model exclude population aged under 20 years-old
(b) Working-age population is composed by population aged 20 to 64 years-old
(c) Old-age-dependency ratio is given by ratio between population aged 65 and over, and working-age population

The skill structure of working-age population also varies heavily with these demographic changes (see Table 4.2). Indeed, by assuming that skill structure of French population remains at its 2010's structure in our baseline scenario, the education distribution of working-age population is characterized by the following features:

- The share of high-skilled in working-age population increases from 19% in 2010 to approximately 36% in 2100.

- Medium-skilled should compose 46.6% of working-age population in 2100 against 34.2% in 2010.
- The weight of low-skilled people in working-age population should decrease over time by diminishing from 48.6% in 2010 to 29.78% in 2100.

This future change in skill structure of French population does not induce a great change in life expectancy of each skill-level. In general, life expectancy at 20 years-old and 60 years-old enhance by respectively 5 and 4 years between 2010 and 2100 for all skill-levels (see Table 4.2). Life expectancy at 20 years-old of low, medium and high skilled people should increase respectively from 61.6, 63.6 and 65.6 years in 2010 to 67.9, 69.2 and 70.6 years in 2100. This expand in longevity is the main driver of aging process in France.

Table 4.2: Life expectancy and skill distribution of active population in baseline (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***High skilled*** | | | | | | | | |
| Share in active population | 19.06% | 23.34% | 27.38% | 30.87% | 33.18% | 34.97% | 36.09% | 36.16% |
| Life expectancy at 20 years | 65.6 | 66.8 | 67.8 | 68.8 | 69.8 | 70.6 | 70.6 | 70.6 |
| Life expectancy at 60 years | 27.5 | 28.5 | 29.3 | 30.1 | 31.0 | 31.6 | 31.6 | 31.6 |
| ***Medium skilled*** | | | | | | | | |
| Share in active population | 34.29% | 39.47% | 43.81% | 46.27% | 46.67% | 46.67% | 46.68% | 46.68% |
| Life expectancy at 20 years | 63.6 | 64.9 | 66.1 | 67.2 | 68.3 | 69.2 | 69.2 | 69.2 |
| Life expectancy at 60 years | 26.0 | 27.0 | 27.9 | 28.8 | 29.7 | 30.4 | 30.4 | 30.4 |
| ***Low skilled*** | | | | | | | | |
| Share in active population | 48.60% | 40.61% | 33.70% | 30.28% | 29.78% | 29.78% | 29.78% | 29.78% |
| Life expectancy at 20 years | 61.6 | 63.1 | 64.4 | 65.7 | 66.9 | 67.9 | 67.9 | 67.9 |
| Life expectancy at 60 years | 24.7 | 25.8 | 26.8 | 27.8 | 28.7 | 29.5 | 29.5 | 29.5 |
| Source: | authors' calculation | | | | | | | |

## 4.3.2 French economy in the baseline

The features of French economy in the baseline are obtained by adopting the assumptions retained by Conseil d'Orientation des Retraites (2012) in their scenario B. These assumptions are similar to those used by *Direction du Trésor* in their official forecasts. These hypothesis are summarized in Table 4.3 and imply that in middle and long term, namely between 2030 et 2060, (i) the annual growth rate of labor productivity reaches 1.5%, (ii) the annual growth rate of GDP attains 1.6% and (iii) the long term unemployment rate is equal to 4.5%.

Table 4.3: Assumptions retained by COR in scenario B

| | | 2011-2020 | 2020-2030 | 2030-2060 |
|---|---|---|---|---|
| Annual growth rate of | labor productivity | 0.9% | 1.5% | 1.5% |
| | GDP | 1.6% | 1.9% | 1.6% |
| Average unemployment rate | | 9.1% | 9.1% | 4.5% |

Source: COR (2012)

### 4.3.3 Social security budget in the baseline

In the baseline, the evolution of social security budget depends mainly on assumptions retained to described the evolution of each component of social security. These assumptions imply that:

- The evolution of retirement expenditures follows the official forecasts provided by Conseil d'Orientation des Retraites (2012) in their scenario B. It implies that, between 2010 and 2020, the share in GDP of retirement expenditures increases from 13.8% in 2010 to 14.2% in 2020. This share decreases at 14% in 2030 and diminish slowly to attain 13.5% in 2100. Note that the slight increase in retirement expenditures should induce a slight rise in pension fund deficit between 2010 and 2040.

- The share in GDP of total health expenditures remains relatively stable after 2010. It implies that the share in GDP of total health expenditures increases from 10.24% in 2010 to 10.73% in 2050. Beyond 2050, the total health expenditures decrease very slightly to reach 10.72% of GDP until 2100. Moreover, we also assume that the share in GDP of public health spending reaches 8.3% until 2100. Furthermore, we assume that the share in GDP of out-of-pocket expenditure on health remains at its 2010's level in the future, namely 0.8%. Thus, to verify the equality between the total health expenditures and out-of-pocket expenditure on health and health spending reimbursed by public and private health insurance, we assume that the share in GDP of health spending reimbursed by private health insurance decreases from 1.72% in 2010 to 1.64% in 2100.

- The shares in GDP of unemployment, social assistance, and family and housing transfers remain constant after 2010. Unemployment, social assistance, and family and housing expenditures then represent respectively 1.9%, 0.6%, 2.8% and 0.8% of GDP between 2010 and 2100.

Table 4.4: Social protection budget (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***Social protection expenditures*** | | | | | | | | |
| (in % of GDP) | 27.64% | 28.62% | 28.41% | 28.32% | 28.01% | 27.88% | 27.89% | 27.89% |
| ***Social contributions*** | | | | | | | | |
| (in % of GDP) | 19.35% | 19.76% | 19.60% | 19.56% | 19.52% | 19.52% | 19.52% | 19.52% |
| ***General Social Contribution*** | | | | | | | | |
| (in % of GDP) | 5.37% | 5.60% | 5.58% | 5.58% | 5.57% | 5.57% | 5.57% | 5.57% |
| ***Financing needs*** | | | | | | | | |
| (in % of GDP) | -0.7% | -1.0% | -1.0% | -0.9% | -0.7% | -0.6% | -0.6% | -0.6% |
| **Unemployment (in % of GDP)** | | | | | | | | |
| - Expenditures | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% |
| - Financing needs | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Social Assistance (in % of GDP)*** | | | | | | | | |
| - Expenditures | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% |
| - Financing needs | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Retirement (in % of GDP)*** | | | | | | | | |
| - Expenditures | 13.8% | 14.2% | 14.0% | 13.9% | 13.6% | 13.5% | 13.5% | 13.5% |
| - Financing needs | -0.7% | -1.0% | -1.0% | -0.9% | -0.7% | -0.6% | -0.6% | -0.6% |
| **Family-Housing (in % of GDP)** | | | | | | | | |
| - Family expenditures | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% |
| - Housing expenditures | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| - Financing needs | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Total health expenditures*** | | | | | | | | |
| (in % of GDP) | 10.24% | 10.73% | 10.73% | 10.73% | 10.72% | 10.72% | 10.72% | 10.72% |
| ***Public health spending (in % of GDP)*** | | | | | | | | |
| - Expenditures | 7.7% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% |
| - Financing needs | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Health spending reimbursed by private insurance*** | | | | | | | | |
| (in % of GDP) | 1.72% | 1.65% | 1.65% | 1.65% | 1.64% | 1.64% | 1.64% | 1.64% |
| ***Out-of-pocket expenditures on health*** | | | | | | | | |
| (in % of GDP) | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |

Source: authors' calculation
(a) Tax rate on wages excludes social contributions and csg, in %

As indicated in Table 4.4, by adopting these assumptions in the baseline, French population aging should only induce a slight increase of the share in GDP of Social Security expenditures during the coming decades. Between 2010 and 2020, this share should increase from 27.64% to 28.62%. However, after 2020, the share in GDP of

Social Security expenditures should decrease and reach 27.89% in 2100. The deficit of this institution should follow the same trend like the share in GDP of Social Security expenditures. The share in GDP of Social Security deficit should increase from 0.7% in 2010 to 1% in 2020 and 2030. After 2030, this share should decrease slowly and attain 0.6% in 2100. Note that the pension fund deficit is the main determinant of the increase in Social Security deficit between 2010 and 2100 in the baseline.

## 4.4 The effects of health spending on French economy

To analyze the future effects of health spending on French economy - by considering the simultaneous impacts of health expenditures on mortality, well-being and labor productivity - we develop an alternative scenario in which the evolution of health spending differs to the one adopted in baseline. For that purpose, in this variant, we retain the official forecasts provided by HCAAM (2013) on the evolution of health spending in France in the coming decades. Based on these official forecasts, the share in GDP of total health expenditures should reach 12.7% and 13.1% in respectively 2040 and 2060. The share in GDP of public health spending should attain 10.1% and 10.4% in respectively 2040 and 2060. To finance this slight increase in public health spending the rate of General Social Contribution varies and ensure the balance of the public health insurance budget at each period. In addition, by assuming that the share in GDP of out-of-pocket expenditure on health remains at its 2010 level, we deduce that the share in GDP of health spending reimbursed by private health insurance should reach 1.8% and 1.9% respectively in 2040 and 2060[8]. After 2060, the shares in GDP of all components of health spending remain stable. Thus, by comparing the results provided by this variant with those obtained in the baseline, we will quantify how far the future increase in health spending improve the mortality, well-being and labor productivity in France.

[8]The flat tax allowing to finance health spending reimbursed by private health insurance varies at each period to balance the budget of private health insurance.

In France, a large part of public health spending is financed by active population whereas a large part of these expenditures is devoted to retired population (see Figure 2). As this particular feature of French health system is retained in the first variant, the simulation outcomes provided by this variant then depend on this characteristic. The following question emerges: could this particular feature of French health system influence the effect of health expenditures on mortality, well-being and labor productivity? To answer this question, we develop a second variant in which the future increase in health spending is mainly financed by French retired population[9]. For that purpose, we assume that, to finance the increase in public health spending, general social contribution of retired people is 1.5 times higher than the one of workers. More precisely, in 2015, the rate of general social contribution applied on retired population income attains 10.2% in scenario 2 compared to 6.3% in scenario 1. At the opposite, in 2015, the rate of general social contribution applied on active population income attains 6.8% in scenario 2 compared to 7.2% in scenario 1. We retain this specification in scenario 2 because, as indicated previously, retired individuals are the main beneficiaries of public health system. One could then think that retired people must increase their contribution to finance the future increase in health spending in order to decrease the fiscal burden carried by workforce to finance the system. Thus, by comparing the results provided by this scenario with the one obtained in the first variant, we quantify how far the effects of health expenditures on mortality, well-being and labor productivity depend on the way of financing health spending in France.

Note that the simulation outcomes provided by the first and second variants should principally exhibit the effect of public health spending on French economy. Indeed, in these scenarios, the share in GDP of public health spending should reach 10.1% in 2040 and 10.4% in 2100 compared to 1.8% in 2040 and 1.9% in 2100 for private health spending and 0.8% in 2040 and 2100 for out-of-pocket expenditure on health. But do simulation results provided by the first and second variants perfectly reflect all potential economic effects of public health spending in France? To answer this question,

[9]In the second scenario, the share in GDP of total health spending, public health spending, private health spending and out-of-pocket expenditure on health should reach respectively 12.7%, 10.1%, 1.8% and 0.8% in 2040, and 13.1%, 10.4%, 1.9% and 0.8% in 2100 like in the first variant.

we develop a third scenario in which the evolution of total health spending follows the official forecasts until 2060 and remains stable after this date (HCAAM 2013). However, we assume that the share in GDP of private health spending and out-of-pocket expenditure on health remain at their 2010 level. Thus, in this scenario, only public health spending drive the increase in total health expenditures between 2010 and 2100. By comparing the results obtained in the third scenario with those provided by the previous ones, we will quantify the potential economic effects of public health spending in France.

But, how far the health spending reimbursed by private health insurance and out-of-pocket expenditure on health affect also French economy? To answer this question, we build two additional variant scenarios (scenarios 4 and 5). In scenario 4, we assume that the shares in GDP of public health spending and out-of-pocket expenditure on health remain at their 2010 level until 2100. This scenario implies that private health spending should have to increase over time to reproduce the official forecast on the evolution of total health spending until 2100. In scenario 5, we maintain the shares in GDP of private and public health spending at their 2010 levels. This scenario involves that only out-of-pocket expenditure on health drives the increase in total health spending until 2100. By comparing the results provided by respectively scenarios 4 and 5, we will quantify the economic effects of health spending reimbursed by private health insurance and out-of-pocket expenditure on health in France. The evolution of each component of French health spending between 2010 and 2100 in each scenario is outlined in Table 4.5. Moreover, to check the robustness of our simulations exercises, for each scenario, except for scenario 2, we perform other simulations in which the demographic bloc is exogenous. These scenarios are named scenario "*bis*". Comparison between original and *bis* scenarios is used to assess the mismeasurement resulting from not considering the effect of health spending on demography and on productivity. Note that, first, the exogenous demographic bloc exploited in scenarios *bis* is extracted from the official population forecasts of INSEE (Blanpain and Chardon 2010). Second, we do not perform scenario *bis* for scenario 2 because this latter is similar to scenario 1.

We highlight in Table 4.6 the percentage points of change compared to baseline of

Table 4.5: The evolution of each component of health spending in % of GDP under each scenario (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***Baseline*** | | | | | | | | |
| *Total health expenditures* | 10.2% | 10.7% | 10.7% | 10.7% | 10.7% | 10.7% | 10.7% | 10.7% |
| *Public health spending* | 7.7% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% |
| *Private health spending* | 1.7% | 1.6% | 1.6% | 1.6% | 1.6% | 1.6% | 1.6% | 1.6% |
| *OOPE on health* | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| ***Scenario 1*** | | | | | | | | |
| *Total health expenditures* | 10.2% | 10.9% | 11.9% | 12.7% | 12.9% | 13.2% | 13.2% | 13.2% |
| *Public health spending* | 7.7% | 8.6% | 9.4% | 10.1% | 10.3% | 10.5% | 10.5% | 10.5% |
| *Private health spending* | 1.7% | 1.5% | 1.7% | 1.8% | 1.9% | 1.9% | 1.9% | 1.9% |
| *OOPE on health* | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| ***Scenario 2*** | | | | | | | | |
| *Total health expenditures* | *10.2%* | *10.9%* | *11.8%* | *12.7%* | *12.9%* | *13.1%* | *13.1%* | *13.1%* |
| *Public health spending* | 7.7% | 8.6% | 9.3% | 10.1% | 10.2% | 10.4% | 10.4% | 10.4% |
| *Private health spending* | 1.7% | 1.5% | 1.7% | 1.8% | 1.9% | 1.9% | 1.9% | 1.9% |
| *OOPE on health* | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| ***Scenario 3*** | | | | | | | | |
| *Total health expenditures* | 10.2% | 10.8% | 11.9% | 12.7% | 13.0% | 13.2% | 13.2% | 13.2% |
| *Public health spending* | 7.7% | 9.3% | 10.1% | 10.9% | 11.1% | 11.3% | 11.3% | 11.3% |
| *Private health spending* | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% |
| *OOPE on health* | 0.8% | 0.0% | 0.0% | 0.1% | 0.1% | 0.2% | 0.2% | 0.2% |
| ***Scenario 4*** | | | | | | | | |
| *Total health expenditures* | 10.2% | 11.1% | 11.9% | 12.7% | 12.9% | 13.1% | 13.1% | 13.1% |
| *Public health spending* | 7.7% | 7.8% | 7.7% | 7.7% | 7.7% | 7.7% | 7.7% | 7.7% |
| *Private health spending* | 1.7% | 1.5% | 1.6% | 1.8% | 1.9% | 1.9% | 1.9% | 1.9% |
| *OOPE on health* | 0.8% | 1.8% | 2.5% | 3.2% | 3.3% | 3.5% | 3.5% | 3.5% |
| ***Scenario 5*** | | | | | | | | |
| *Total health expenditures* | 10.2% | 11.1% | 11.9% | 12.7% | 12.7% | 13.1% | 13.1% | 13.1% |
| *Public health spending* | 7.7% | 7.8% | 7.7% | 7.7% | 7.7% | 7.7% | 7.7% | 7.7% |
| *Private health spending* | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% | 1.7% |
| *OOPE on health* | 0.8% | 1.6% | 2.5% | 3.3% | 3.5% | 3.7% | 3.7% | 3.7% |

Source: authors' calculation

each component of health spending under each scenario. It appears that our forecasts on French health spending are robust with respect to assumptions on demographic bloc. Indeed, there is no significant difference between the forecasts on health spending provided by original and *bis* scenarios. Moreover, we can see in Table 4.6 that as the general social contribution allows to balance the public health insurance budget at each period, each scenario has a neutral effect on public health insurance deficit.

### 4.4.1 The demographic consequences of French health spending

To quantify the demographic effects of the future rise in French health spending, we exploit the explicit link established between health spending, health status and mortality rates. This explicit link implies that health expenditures should improve health status (see equation 4.12), the health enhancement should reduce the mortality rates (see equation 4.11) and the decreases in mortality rates should extend the lifetime.

The life gains resulting from the increase in French health expenditures are reported in Table 4.7. The life gains are expressed in number of months earned due to increase in health spending compared to baseline. It appears that life gains are not uniformly shared across skill-level and across age. According to Table 4.7, whatever the scenario, low-skill population should benefit higher life gains than medium- and high-skill population. This result suggests that the future increase in health spending should allow to low-skilled to catch up the life expectancy of skilled individuals. At the opposite, the future rise in health expenditures should not improve substantially the life expectancy of skilled people because may be in long term their life expectancy should reach a physiological boundary. Beyond this physiological boundary, health spending should not then be able to improve significantly the life expectancy of skilled population. Moreover, the life gains should be more important for young people than for retired one because the future rise in health spending should mainly affect the future generations. However, these life gains are not very significant for both young and old people. In average, the life expectancy at 20 years-old should improve by 2 months compared to

Table 4.6: The percentage points of change compared to baseline of each component of health spending under alternative scenarios (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| **Total health expenditures (in % of GDP)** | | | | | | | | |
| - Baseline | 10.24% | 10.73% | 10.73% | 10.73% | 10.72% | 10.72% | 10.72% | 10.72% |
| - Scenario 1 | 0.00% | 0.18% | 1.14% | 1.98% | 2.22% | 2.44% | 2.46% | 2.46% |
| - Scenario 1 bis | 0.00% | 0.18% | 1.14% | 1.97% | 2.20% | 2.42% | 2.43% | 2.43% |
| - Scenario 2 | 0.00% | 0.19% | 1.11% | 1.93% | 2.16% | 2.38% | 2.40% | 2.40% |
| - Scenario 3 | 0.00% | 0.11% | 1.14% | 2.00% | 2.24% | 2.46% | 2.48% | 2.48% |
| - Scenario 3 bis | 0.00% | 0.11% | 1.14% | 2.00% | 2.23% | 2.44% | 2.46% | 2.45% |
| - Scenario 4 | 0.00% | 0.33% | 1.18% | 1.96% | 2.16% | 2.37% | 2.39% | 2.39% |
| - Scenario 4 bis | 0.00% | 0.33% | 1.18% | 1.95% | 2.14% | 2.35% | 2.36% | 2.36% |
| - Scenario 5 | 0.00% | 0.33% | 1.19% | 1.96% | 2.16% | 2.37% | 2.39% | 2.39% |
| - Scenario 5 bis | 0.00% | 0.32% | 1.19% | 1.96% | 2.14% | 2.35% | 2.36% | 2.36% |
| ***Public health spending (in % of GDP)*** | | | | | | | | |
| Expenditures | | | | | | | | |
| - Baseline | 7.7% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% |
| - Scenario 1 | 0.0% | 0.3% | 1.1% | 1.8% | 2.0% | 2.2% | 2.2% | 2.2% |
| - Scenario 1 bis | 0.0% | 0.3% | 1.1% | 1.8% | 2.0% | 2.1% | 2.1% | 2.1% |
| - Scenario 2 | 0.0% | 0.3% | 1.0% | 1.8% | 1.9% | 2.1% | 2.1% | 2.1% |
| - Scenario 3 | 0.0% | 1.0% | 1.8% | 2.6% | 2.8% | 3.0% | 3.0% | 3.0% |
| - Scenario 3 bis | 0.0% | 1.0% | 1.8% | 2.6% | 2.8% | 2.9% | 2.9% | 2.9% |
| - Scenario 4 | 0.0% | -0.5% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% |
| - Scenario 4 bis | 0.0% | -0.5% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% |
| - Scenario 5 | 0.0% | -0.5% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% |
| - Scenario 5 bis | 0.0% | -0.5% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% | -0.6% |
| Financing needs | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 bis | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 bis | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 bis | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Health spending reimbursed by private insurance (in % of GDP)*** | | | | | | | | |
| - Baseline | 1.72% | 1.65% | 1.65% | 1.65% | 1.64% | 1.64% | 1.64% | 1.64% |
| - Scenario 1 | 0.0% | -0.1% | 0.1% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| - Scenario 1 bis | 0.0% | -0.1% | 0.1% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| - Scenario 2 | 0.0% | -0.1% | 0.1% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| - Scenario 3 | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| - Scenario 3 bis | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| - Scenario 4 | 0.0% | -0.1% | 0.1% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| - Scenario 4 bis | 0.0% | -0.1% | 0.1% | 0.2% | 0.2% | 0.3% | 0.3% | 0.3% |
| - Scenario 5 | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| - Scenario 5 bis | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| ***Out-of-pocket expenditures on health (in % of GDP)*** | | | | | | | | |
| - Baseline | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| - Scenario 1 | 0.00% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis | 0.00% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 | 0.00% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 | 0.00% | -1.0% | -0.8% | -0.7% | -0.6% | -0.6% | -0.6% | -0.6% |
| - Scenario 3 bis | 0.00% | -1.0% | -0.8% | -0.7% | -0.6% | -0.6% | -0.6% | -0.6% |
| - Scenario 4 | 0.00% | 1.0% | 1.7% | 2.4% | 2.5% | 2.7% | 2.7% | 2.7% |
| - Scenario 4 bis | 0.00% | 1.0% | 1.7% | 2.4% | 2.5% | 2.7% | 2.7% | 2.7% |
| - Scenario 5 | 0.00% | 0.8% | 1.7% | 2.5% | 2.7% | 2.9% | 2.9% | 2.9% |
| - Scenario 5 bis | 0.00% | 0.8% | 1.7% | 2.5% | 2.7% | 2.9% | 2.9% | 2.9% |

Source: authors' calculation

Table 4.7: Life expectancy of active population under alternative scenarios (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***High skilled*** | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | |
| - Baseline (years) | 65.6 | 66.8 | 67.8 | 68.8 | 69.8 | 70.6 | 70.6 | 70.6 |
| - Scenario 1 (a) | 0.0 | 0.2 | 1.2 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| - Scenario 2 (a) | 0.0 | 0.3 | 1.2 | 1.7 | 1.7 | 1.7 | 1.7 | 1.7 |
| - Scenario 3 (a) | 0.0 | 0.1 | 1.1 | 1.7 | 1.7 | 1.6 | 1.6 | 1.6 |
| - Scenario 4 (a) | 0.0 | 0.5 | 1.4 | 1.9 | 1.9 | 1.8 | 1.8 | 1.8 |
| - Scenario 5 (a) | 0.0 | 0.5 | 1.4 | 1.9 | 1.9 | 1.8 | 1.8 | 1.8 |
| Life expectancy at 60 years-old | | | | | | | | |
| - Baseline (years) | 27.5 | 28.5 | 29.3 | 30.1 | 31.0 | 31.6 | 31.6 | 31.6 |
| - Scenario 1 (a) | 0.0 | 0.2 | 0.8 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| - Scenario 2 (a) | 0.0 | 0.2 | 0.8 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| - Scenario 3 (a) | 0.0 | 0.1 | 0.8 | 1.2 | 1.2 | 1.2 | 1.2 | 1.2 |
| - Scenario 4 (a) | 0.0 | 0.3 | 1.0 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| - Scenario 5 (a) | 0.0 | 0.3 | 1.0 | 1.4 | 1.3 | 1.3 | 1.3 | 1.3 |
| ***Medium skilled*** | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | |
| - Baseline (years) | 63.6 | 64.9 | 66.1 | 67.2 | 68.3 | 69.2 | 69.2 | 69.2 |
| - Scenario 1 (a) | 0.0 | 0.3 | 1.3 | 2.0 | 1.9 | 1.9 | 1.9 | 1.9 |
| - Scenario 2 (a) | 0.0 | 0.3 | 1.3 | 2.0 | 1.9 | 1.9 | 1.9 | 1.9 |
| - Scenario 3 (a) | 0.0 | 0.1 | 1.3 | 1.9 | 1.9 | 1.9 | 1.9 | 1.9 |
| - Scenario 4 (a) | 0.0 | 0.6 | 1.6 | 2.2 | 2.1 | 2.1 | 2.1 | 2.1 |
| - Scenario 5 (a) | 0.0 | 0.6 | 1.6 | 2.2 | 2.2 | 2.1 | 2.1 | 2.1 |
| Life expectancy at 60 years-old | | | | | | | | |
| - Baseline (years) | 26.0 | 27.0 | 27.9 | 28.8 | 29.7 | 30.4 | 30.4 | 30.4 |
| - Scenario 1 (a) | 0.0 | 0.2 | 0.9 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| - Scenario 2 (a) | 0.0 | 0.2 | 0.9 | 1.3 | 1.4 | 1.3 | 1.3 | 1.3 |
| - Scenario 3 (a) | 0.0 | 0.1 | 0.9 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| - Scenario 4 (a) | 0.0 | 0.4 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| - Scenario 5 (a) | 0.0 | 0.4 | 1.1 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| ***Low skilled*** | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | |
| - Baseline (years) | 61.6 | 63.1 | 64.4 | 65.7 | 66.9 | 67.9 | 67.9 | 67.9 |
| - Scenario 1 (a) | 0.0 | 0.3 | 1.5 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 |
| - Scenario 2 (a) | 0.0 | 0.3 | 1.5 | 2.3 | 2.3 | 2.2 | 2.2 | 2.2 |
| - Scenario 3 (a) | 0.0 | 0.1 | 1.5 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| - Scenario 4 (a) | 0.0 | 0.7 | 1.8 | 2.6 | 2.5 | 2.5 | 2.4 | 2.5 |
| - Scenario 5 (a) | 0.0 | 0.6 | 1.9 | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 |
| Life expectancy at 60 years-old | | | | | | | | |
| - Baseline (years) | 24.7 | 25.8 | 26.8 | 27.8 | 28.7 | 29.5 | 29.5 | 29.5 |
| - Scenario 1 (a) | 0.0 | 0.2 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| - Scenario 2 (a) | 0.0 | 0.2 | 1.0 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| - Scenario 3 (a) | 0.0 | 0.1 | 0.9 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| - Scenario 4 (a) | 0.0 | 0.4 | 1.2 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 |
| - Scenario 5 (a) | 0.0 | 0.4 | 1.2 | 1.7 | 1.6 | 1.6 | 1.6 | 1.6 |

Source: authors' calculation
(a) Change in number of months compared to baseline

baseline in 2060 whatever the scenario. The life expectancy at 60 years-old should increase by only 1 month in average compared to baseline in 2060.

Table 4.8: French population under alternative scenarios (2010-2100)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***Total population (a)*** | | | | | | | | |
| - Baseline (x1000) | 47 502 | 50 159 | 52 692 | 54 796 | 56 002 | 57 117 | 58 885 | 59 869 |
| - Scenario 1 (e) | 0.00% | 0.00% | 0.04% | 0.11% | 0.17% | 0.19% | 0.20% | 0.20% |
| - Scenario 2 (e) | 0.00% | 0.00% | 0.04% | 0.11% | 0.17% | 0.19% | 0.20% | 0.20% |
| - Scenario 3 (e) | 0.00% | 0.00% | 0.03% | 0.10% | 0.17% | 0.19% | 0.19% | 0.20% |
| - Scenario 4 (e) | 0.00% | 0.01% | 0.05% | 0.14% | 0.20% | 0.22% | 0.22% | 0.22% |
| - Scenario 5 (e) | 0.00% | 0.01% | 0.05% | 0.14% | 0.20% | 0.22% | 0.22% | 0.22% |
| ***Working-age population (b)*** | | | | | | | | |
| - Baseline (x1000) | 36 937 | 36 727 | 36 675 | 36 675 | 37 220 | 37 677 | 38 415 | 38 985 |
| - Scenario 1 (e) | 0.00% | 0.00% | 0.01% | 0.03% | 0.04% | 0.04% | 0.04% | 0.04% |
| - Scenario 2 (e) | 0.00% | 0.00% | 0.01% | 0.03% | 0.04% | 0.04% | 0.04% | 0.04% |
| - Scenario 3 (e) | 0.00% | 0.00% | 0.01% | 0.03% | 0.04% | 0.04% | 0.04% | 0.04% |
| - Scenario 4 (e) | 0.00% | 0.00% | 0.02% | 0.03% | 0.04% | 0.04% | 0.04% | 0.04% |
| - Scenario 5 (e) | 0.00% | 0.00% | 0.02% | 0.03% | 0.04% | 0.04% | 0.04% | 0.04% |
| ***Population aged 65 years-old and over*** | | | | | | | | |
| - Baseline (x1000) | 10 565 | 13 432 | 16 017 | 18 121 | 18 783 | 19 440 | 20 469 | 20 884 |
| - Scenario 1 (e) | 0.00% | 0.01% | 0.09% | 0.28% | 0.44% | 0.49% | 0.50% | 0.50% |
| - Scenario 2 (e) | 0.00% | 0.01% | 0.10% | 0.28% | 0.44% | 0.49% | 0.50% | 0.50% |
| - Scenario 3 (e) | 0.00% | 0.00% | 0.07% | 0.26% | 0.42% | 0.48% | 0.49% | 0.49% |
| - Scenario 4 (e) | 0.00% | 0.02% | 0.14% | 0.35% | 0.50% | 0.55% | 0.55% | 0.55% |
| - Scenario 5 (e) | 0.00% | 0.02% | 0.14% | 0.35% | 0.51% | 0.55% | 0.55% | 0.55% |
| ***Old-age-dependency ratio (c )*** | | | | | | | | |
| - Baseline (x1000) | 28.60% | 36.57% | 43.67% | 49.41% | 50.46% | 51.60% | 53.28% | 53.57% |
| - Scenario 1 (f) | 0.00% | 0.00% | 0.04% | 0.13% | 0.20% | 0.23% | 0.25% | 0.25% |
| - Scenario 2 (f) | 0.00% | 0.00% | 0.04% | 0.13% | 0.20% | 0.23% | 0.25% | 0.25% |
| - Scenario 3 (f) | 0.00% | 0.00% | 0.03% | 0.12% | 0.19% | 0.23% | 0.24% | 0.24% |
| - Scenario 4 (f) | 0.00% | 0.01% | 0.05% | 0.15% | 0.23% | 0.26% | 0.27% | 0.27% |
| - Scenario 5 (f) | 0.00% | 0.01% | 0.05% | 0.16% | 0.23% | 0.26% | 0.27% | 0.27% |

Source: authors' calculation
(a) Total population in model does not include population aged under 20 years-old
(b) Working-age population is composed by population aged 20 to 64 years-old
(c) Old-age-dependency ratio is given by ratio between population aged 65 and over, and working-age population
(e) Change in percent of baseline
(f) Percentage points of change compared to baseline

Despite of the slight effect of health spending on life expectancy, the raise in lifetime should extend the size of retired population according to Table 4.8. We obtain this result because by definition, the rise in life expectancy reflects the increase in lifetime, the rise in lifetime increases the number of retired people being alive at each period and implies necessarily an increase in size of retired population. In our case, it appears that in average, the size of population aged 65 and over should increase by 0.3% in 2040 and 0.5% in 2100 compared to baseline. This slight rise in size of retired population should also increase the old-age dependency ratio. This ratio should progress by more than

0.1 and 0.24 percentage points compared to baseline in respectively 2040 and 2100. In other words, the future rise in health spending should not amplify the aging process in France even if these expenditures increase the size of retired population.

Note that as health expenditures only influence mortality rates, the future rise in health spending should not affect French population growth. That is why the increase in size of French population resulting from the rise in health spending is really tiny. French population should increase by around 0.20% in 2100 compared to baseline if total health spending raise by more than 2 percentage points compared to baseline at the same period as indicated in Table 4.6. The slight increase in size of French population resulting from the rise in health spending is mainly explained by the rise in size of retired population.

### 4.4.2 The economic consequences of health spending in France

To identify the economic effects of French health spending, we exploit the explicit link between health expenditures, health status and labor productivity. This explicit link involves that health spending should affect positively health status (see equation 4.12), the health improvement should enhance labor efficiency (see equation 4.3) and the labor efficiency enhancement should ameliorate labor productivity.

The occurrence of this mechanism in our AGEM-OLG is illustrated by the future increase in human capital in health form as indicated in Table 4.9. Indeed, the average efficient labor per worker varies positively with increase in health expenditures. In average, whatever the scenario, if increase in total health spending follows the official forecasts of HCAAM (2013), the average efficient labor per worker should grow by 3% in 2040 and 3.5% in 2060 compared to baseline[10]. However, as indicated in Table 4.9, the labor productivity gains resulting from the efficient labor improvement should not be necessarily able to generate more economic growth compared to baseline in middle

[10] Note that there is a similarity between the average efficient labor in baseline and in all scenarios *bis*. This similarity is due to the exogenous demographic bloc used in scenarios *bis* providing in fact from the endogenous demographic bloc in baseline. In addition, in scenarios *bis*, we assume no link between health spending and health status in order to obtain this exogenous demographic bloc. That is why the evolution of efficient labor in scenarios *bis* compared to baseline is slightly negative.

Table 4.9: Main macroeconomic aggregates under alternative scenarios (1)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***GDP per capita (base 2010 = 1)*** | | | | | | | | |
| - Baseline | 1.00 | 1.12 | 1.21 | 1.33 | 1.47 | 1.63 | 1.98 | 2.44 |
| - Scenario 1 (b) | 0.00% | 0.05% | -0.56% | -1.06% | -1.40% | -1.57% | -1.63% | -1.62% |
| - Scenario 1 bis (b) | 0.00% | 0.03% | -0.64% | -1.13% | -1.40% | -1.54% | -1.56% | -1.55% |
| - Scenario 2 (b) | 0.00% | 0.20% | -0.24% | -0.66% | -0.95% | -1.11% | -1.18% | -1.18% |
| - Scenario 3 (b) | 0.00% | -0.26% | -1.06% | -1.67% | -2.03% | -2.21% | -2.25% | -2.24% |
| - Scenario 3 bis (b) | 0.00% | -0.28% | -1.15% | -1.74% | -2.04% | -2.17% | -2.18% | -2.17% |
| - Scenario 4 (b) | 0.00% | 0.80% | 1.10% | 1.12% | 0.92% | 0.81% | 0.68% | 0.68% |
| - Scenario 4 bis (b) | 0.00% | 0.76% | 1.02% | 1.06% | 0.92% | 0.86% | 0.76% | 0.76% |
| - Scenario 5 (b) | 0.00% | 0.78% | 1.17% | 1.19% | 1.00% | 0.88% | 0.74% | 0.74% |
| - Scenario 5 bis (b) | 0.00% | 0.75% | 1.09% | 1.13% | 1.00% | 0.93% | 0.82% | 0.82% |
| ***Tax rate on wages (a)*** | | | | | | | | |
| - Baseline | 14.2% | 13.3% | 13.7% | 13.8% | 13.6% | 13.5% | 13.5% | 13.6% |
| - Scenario 1 (c) | 0.00% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% |
| - Scenario 1 bis (c) | 0.00% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% |
| - Scenario 2 (c) | 0.00% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% |
| - Scenario 3 (c) | 0.00% | -0.1% | 0.0% | 0.0% | 0.1% | 0.0% | -0.1% | -0.1% |
| - Scenario 3 bis (c) | 0.00% | -0.1% | 0.0% | 0.1% | 0.0% | 0.0% | -0.1% | -0.2% |
| - Scenario 4 (c) | 0.00% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.1% | 0.0% |
| - Scenario 4 bis (c) | 0.00% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 (c) | 0.00% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.1% | 0.0% |
| - Scenario 5 bis (c) | 0.00% | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% |
| ***Average human capital in education form per worker (base 2010 = 1)*** | | | | | | | | |
| - Baseline | 1.000 | 1.173 | 1.294 | 1.334 | 1.340 | 1.338 | 1.340 | 1.339 |
| - Scenario 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Average experience per worker (base 2010 = 1)*** | | | | | | | | |
| - Baseline | 1.000 | 1.005 | 0.993 | 0.992 | 0.996 | 1.000 | 0.998 | 1.000 |
| - Scenario 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Average efficient labor per worker (base 2010 = 1)*** | | | | | | | | |
| - Baseline | 1.000 | 1.187 | 1.468 | 1.805 | 2.202 | 2.706 | 2.711 | 2.711 |
| - Scenario 1 (b) | 0.0% | 0.3% | 1.7% | 2.9% | 3.2% | 3.4% | 3.4% | 3.4% |
| - Scenario 1 bis (b) | 0.0% | -0.1% | -0.2% | -0.2% | -0.2% | -0.2% | 0.0% | 0.0% |
| - Scenario 2 (b) | 0.0% | 0.4% | 1.8% | 2.9% | 3.2% | 3.4% | 3.4% | 3.4% |
| - Scenario 3 (b) | 0.0% | 0.2% | 1.7% | 2.8% | 3.1% | 3.3% | 3.4% | 3.3% |
| - Scenario 3 bis (b) | 0.0% | -0.1% | -0.2% | -0.2% | -0.2% | -0.2% | 0.0% | 0.0% |
| - Scenario 4 (b) | 0.0% | 0.7% | 2.1% | 3.3% | 3.5% | 3.7% | 3.7% | 3.7% |
| - Scenario 4 bis (b) | 0.0% | -0.1% | -0.2% | -0.2% | -0.2% | -0.2% | 0.0% | 0.0% |
| - Scenario 5 (b) | 0.0% | 0.7% | 2.1% | 3.3% | 3.5% | 3.8% | 3.8% | 3.8% |
| - Scenario 5 bis (b) | 0.0% | -0.1% | -0.2% | -0.2% | -0.2% | -0.2% | 0.0% | 0.0% |

Source: authors' calculation
(a) Tax rate on wages excludes social contributions and csg, in %
(b) Change in percent of baseline
(c ) Percentage points of change compared to baseline

and long term. It seems that improving labor productivity by having high level of public health spending like in scenarios 1, 2 and 3 could have a negative effect on economic growth. The level of GDP per capita is less important than in baseline in these scenarios.

The negative effect of public health spending on economic growth is highlighted by simulation outcomes provided by scenario 3. In this scenario, the GDP per capita should reduce by 1.67% in 2040 and 2.21% in 2060 compared to baseline. At the opposite, improving efficient labor by increasing the levels of health spending reimbursed by private health insurance (scenario 4) and out-of-pocket expenditure on health (scenario 5) could generate labor productivity gains able to increase the GDP per capita compared to baseline. As illustrated in scenario 5, if the increase in total health spending is mainly driven by the rise in out-of-pocket expenditure on health, the GDP per capita should increase by 1.19% in 2040 and 0.88% in 2060 compared to baseline.

The negative effect of public health spending on economic growth is explained by the crowding-out effect generated by public health spending. This crowding-out effect is explained by the way of financing public health spending in France. Indeed, public health spending is financed through social contributions and general social contribution levied on income received by each agent. As general social contribution varies at each period to ensure the balance of public health insurance budget, any increase in public health spending is accompanied by a rise in general social contribution rate. A rise in general social contribution rate reduces the available income of each agent and decreases at the same time the individual saving. The reduction of saving has a negative effect on physical capital stock, on labor productivity and then on economic growth. This mechanism explains the crowding-out effect generated by public health spending.

Results outlined in Table 4.10 illustrate perfectly this crowding-out effect arising from public health expenditure in France. In scenarios 4 and 5, any increase in GDP per capita compared to baseline is accompanied by an increase in average net wage and a decrease in interest rate. The decrease in interest rate in scenarios 4 and 5 illustrates the increase in physical capital stock in French economy allowing this additional economic

Table 4.10: Main macroeconomic aggregates under alternative scenarios (2)

| | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|
| ***Skill premium (secondary school - in %)*** | | | | | | | | |
| - Baseline | 173.84% | 170.48% | 171.54% | 171.41% | 171.46% | 171.38% | 171.37% | 171.33% |
| - Scenario 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Experience premium (20 years of experience - in %)*** | | | | | | | | |
| - Baseline | 32.84% | 32.68% | 32.28% | 32.30% | 32.30% | 32.35% | 32.31% | 32.11% |
| - Scenario 1 (b) | 0.0% | 0.5% | 0.3% | 0.2% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 1 bis (b) | 0.0% | 0.5% | 0.3% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 2 (b) | 0.0% | 0.4% | 0.3% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 (b) | 0.0% | 0.6% | 0.3% | 0.2% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 bis (b) | 0.0% | 0.6% | 0.3% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 (b) | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 4 bis (b) | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 (b) | 0.0% | -0.1% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| - Scenario 5 bis (b) | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| ***Average wage for 15-65 years (base 2010 = 1)*** | | | | | | | | |
| - Baseline | 1.000 | 1.241 | 1.342 | 1.537 | 1.752 | 1.933 | 2.418 | 2.953 |
| - Scenario 1 (b) | 0.0% | -0.5% | -2.4% | -4.1% | -4.6% | -5.0% | -5.0% | -5.0% |
| - Scenario 1 bis (b) | 0.0% | -0.5% | -2.5% | -4.2% | -4.8% | -5.1% | -5.1% | -5.0% |
| - Scenario 2 (b) | 0.0% | 0.3% | -1.3% | -2.8% | -3.3% | -3.7% | -3.7% | -3.7% |
| - Scenario 3 (b) | 0.0% | -2.0% | -4.2% | -6.0% | -6.6% | -7.0% | -6.9% | -6.9% |
| - Scenario 3 bis (b) | 0.0% | -2.0% | -4.3% | -6.2% | -6.8% | -7.1% | -7.0% | -6.9% |
| - Scenario 4 (b) | 0.0% | 1.9% | 2.4% | 2.4% | 2.2% | 2.0% | 1.8% | 1.8% |
| - Scenario 4 bis (b) | 0.0% | 1.8% | 2.2% | 2.2% | 2.0% | 1.9% | 1.7% | 1.8% |
| - Scenario 5 (b) | 0.0% | 1.9% | 2.4% | 2.5% | 2.3% | 2.1% | 1.9% | 1.9% |
| - Scenario 5 bis (b) | 0.0% | 1.8% | 2.3% | 2.3% | 2.1% | 2.0% | 1.8% | 1.8% |
| ***Return on capital (annual real interest rate) (in percent)*** | | | | | | | | |
| - Baseline | 3.26% | 3.58% | 4.09% | 4.24% | 4.36% | 4.41% | 4.45% | 4.54% |
| - Scenario 1 (c) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% |
| - Scenario 1 bis (c) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% |
| - Scenario 2 (c) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - Scenario 3 (c) | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| - Scenario 3 bis (c) | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| - Scenario 4 (c) | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - Scenario 4 bis (c) | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - Scenario 5 (c) | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - Scenario 5 bis (c) | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |

Source: authors' calculation
(b) Change in percent of baseline
(c ) Percentage points of change compared to baseline

growth. At the opposite, in scenarios 1, 2 and 3, the average net wage decreases when public health spending increases. At the same time, the interest rate increases in long term and GDP per capita becomes lower than the one in baseline. In scenarios 1, 2 and 3, the crowding-out effect is then more important than the positive effect of public health spending on efficient labor and induces therefore a decrease in GDP per capita compared to baseline contrariwise to scenarios 4 and 5.

### 4.4.3 The effect of health spending on Social Security budget

To measure the rise in general social contribution inducing the crowding-out effect highlighted in the previous Section, we focus on the evolution of Social security budget when the public health spending increase. This evolution is informed in Table 4.11. It appears that to finance the rise in public health spending (scenarios 1, 2 and 3), in order to ensure the balance of public health insurance budget, the increase in general social contribution rate implies a significant rise in share in GDP of general social contribution. In scenarios 1, 2 and 3, the share in GDP of general social contribution should have to upgrade by 2 and 3 percentage points compared to baseline in respectively 2040 and 2060 to ensure the balance of public health insurance budget. At the opposite, maintaining unchanged the share in GDP of public health spending after 2010 should reduce slightly the share in GDP of general social contribution. That is why in scenario 4 and 5, the crowding-out effect does not occur.

One component of social security budget which should also vary with the future rise in health spending is retirement expenditures. Indeed, our specification on the explicit link between health spending, health status and life expectancy implies that the increase in health spending should improve life expectancy, expend the size of retired population, rise retirement expenditures and increase social protection expenditures. However, it seems that this mechanism should not really occur in the coming decades. According to Table 4.12, whatever the scenario, the future rise in health spending should not affect significantly the evolution of retirement expenditures compared to baseline. This result is explained by the fact that the increase in size of retired pop-

Table 4.11: Social protection under alternative scenarios (1)

| | | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|---|
| ***Social protection expenditures (in % of GDP)*** | | | | | | | | | |
| | - Baseline | 27.64% | 28.62% | 28.41% | 28.32% | 28.01% | 27.88% | 27.89% | 27.89% |
| | - Scenario 1 (a) | 0.00% | 0.31% | 1.18% | 2.02% | 2.24% | 2.40% | 2.34% | 2.30% |
| | - Scenario 1 bis (a) | 0.00% | 0.31% | 1.19% | 2.02% | 2.21% | 2.34% | 2.26% | 2.23% |
| | - Scenario 2 (a) | 0.00% | 0.29% | 1.10% | 1.92% | 2.14% | 2.30% | 2.26% | 2.23% |
| | - Scenario 3 (a) | 0.00% | 1.07% | 2.05% | 2.92% | 3.13% | 3.26% | 3.18% | 3.14% |
| | - Scenario 3 bis (a) | 0.00% | 1.08% | 2.07% | 2.92% | 3.10% | 3.20% | 3.10% | 3.06% |
| | - Scenario 4 (a) | 0.00% | -0.69% | -0.76% | -0.74% | -0.65% | -0.58% | -0.53% | -0.55% |
| | - Scenario 4 bis (a) | 0.00% | -0.68% | -0.75% | -0.75% | -0.69% | -0.64% | -0.61% | -0.62% |
| | - Scenario 5 (a) | 0.00% | -0.68% | -0.77% | -0.75% | -0.66% | -0.59% | -0.53% | -0.55% |
| | - Scenario 5 bis (a) | 0.00% | -0.68% | -0.76% | -0.76% | -0.70% | -0.65% | -0.61% | -0.62% |
| ***Social contributions (in % of GDP)*** | | | | | | | | | |
| | - Baseline | 19.35% | 19.76% | 19.60% | 19.56% | 19.52% | 19.52% | 19.52% | 19.52% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***General Social Contribution (in % of GDP)*** | | | | | | | | | |
| | - Baseline | 5.37% | 5.60% | 5.58% | 5.58% | 5.57% | 5.57% | 5.57% | 5.57% |
| | - Scenario 1 (a) | 0.00% | 0.41% | 1.27% | 2.13% | 2.34% | 2.54% | 2.55% | 2.55% |
| | - Scenario 1 bis (a) | 0.00% | 0.40% | 1.27% | 2.12% | 2.32% | 2.52% | 2.53% | 2.53% |
| | - Scenario 2 (a) | 0.00% | 0.01% | 0.78% | 1.55% | 1.74% | 1.92% | 1.94% | 1.94% |
| | - Scenario 3 (a) | 0.00% | 1.26% | 2.19% | 3.06% | 3.27% | 3.47% | 3.50% | 3.49% |
| | - Scenario 3 bis (a) | 0.00% | 1.26% | 2.19% | 3.06% | 3.26% | 3.45% | 3.47% | 3.46% |
| | - Scenario 4 (a) | 0.00% | -0.65% | -0.68% | -0.69% | -0.69% | -0.69% | -0.68% | -0.68% |
| | - Scenario 4 bis (a) | 0.00% | -0.65% | -0.68% | -0.69% | -0.71% | -0.70% | -0.70% | -0.70% |
| | - Scenario 5 (a) | 0.00% | -0.65% | -0.67% | -0.69% | -0.69% | -0.69% | -0.68% | -0.67% |
| | - Scenario 5 bis (a) | 0.00% | -0.65% | -0.67% | -0.69% | -0.71% | -0.70% | -0.70% | -0.69% |
| ***Financing needs (in % of GDP)*** | | | | | | | | | |
| | - Baseline | -0.70% | -1.00% | -1.00% | -0.90% | -0.70% | -0.60% | -0.60% | -0.60% |
| | - Scenario 1 (a) | 0.00% | -0.01% | 0.12% | 0.21% | 0.25% | 0.24% | 0.17% | 0.14% |
| | - Scenario 1 bis (a) | 0.00% | 0.00% | 0.13% | 0.21% | 0.23% | 0.21% | 0.12% | 0.09% |
| | - Scenario 2 (a) | 0.00% | -0.03% | 0.06% | 0.15% | 0.19% | 0.19% | 0.14% | 0.11% |
| | - Scenario 3 (a) | 0.00% | 0.05% | 0.21% | 0.31% | 0.33% | 0.30% | 0.21% | 0.17% |
| | - Scenario 3 bis (a) | 0.00% | 0.06% | 0.22% | 0.31% | 0.31% | 0.27% | 0.15% | 0.12% |
| | - Scenario 4 (a) | 0.00% | -0.15% | -0.18% | -0.14% | -0.06% | 0.00% | 0.04% | 0.02% |
| | - Scenario 4 bis (a) | 0.00% | -0.14% | -0.17% | -0.15% | -0.08% | -0.04% | -0.02% | -0.03% |
| | - Scenario 5 (a) | 0.00% | -0.14% | -0.19% | -0.15% | -0.07% | -0.01% | 0.04% | 0.02% |
| | - Scenario 5 bis (a) | 0.00% | -0.14% | -0.18% | -0.16% | -0.09% | -0.05% | -0.02% | -0.04% |
| ***Unemployment (in % of GDP)*** | | | | | | | | | |
| Expenditures | - Baseline | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Social Assistance (in % of GDP)*** | | | | | | | | | |
| Expenditures | - Baseline | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

Source: authors' calculation
(a) Percentage points of change compared to baseline

Table 4.12: Social protection under alternative scenarios (2)

| | | *2010* | *2020* | *2030* | *2040* | *2050* | *2060* | *2080* | *2100* |
|---|---|---|---|---|---|---|---|---|---|
| ***Retirement (in % of GDP)*** | | | | | | | | | |
| Expenditures | - Baseline | 13.8% | 14.2% | 14.0% | 13.9% | 13.6% | 13.5% | 13.5% | 13.5% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.1% | 0.2% | 0.2% | 0.2% | 0.1% | 0.1% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.1% | 0.2% | 0.2% | 0.2% | 0.1% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.1% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.1% | 0.1% | 0.1% |
| | - Scenario 4 bis (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.1% | 0.1% | 0.1% |
| | - Scenario 5 bis (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | - Baseline | -0.7% | -1.0% | -1.0% | -0.9% | -0.7% | -0.6% | -0.6% | -0.6% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.1% | 0.2% | 0.2% | 0.2% | 0.1% | 0.1% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.1% | 0.2% | 0.2% | 0.2% | 0.1% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.2% | 0.2% | 0.2% | 0.1% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.1% | 0.1% | 0.1% |
| | - Scenario 4 bis (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.1% | 0.1% | 0.1% |
| | - Scenario 5 bis (a) | 0.0% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Family-Housing (in % of GDP)*** | | | | | | | | | |
| Family expenditures | - Baseline | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Housing expenditures | - Baseline | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% |
| | - Scenario 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 3 (a) | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 3 bis (a) | 0.0% | 0.0% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| | - Scenario 4 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 4 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | - Scenario 5 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

Source: authors' calculation
(a) Percentage points of change compared to baseline

ulation obtained with the rise in health spending should not be substantial to have a significant effect on retirement expenditures.

As the rise in retirement expenditures resulting from the increase in health spending should not be substantial, the rise in share in GDP of social protection expenditures observed in scenarios 1, 2 and 3 are then not explained by the evolution of retirement expenditures. The rise in share in GDP of social protection expenditures observed in these scenarios are mainly induced by the rise in public health expenditures. Indeed, in these scenarios the future increase in health spending is principally driven by the rise in public health spending. However, the rise in public health expenditures increases the social protection expenditures. That is why, if public health spending evolution follows the official forecasts, the share in GDP of social protection expenditures should increase by 2 and 2.4 percentage points compared to baseline in respectively 2040 and 2060 (see scenarios 1 and 2). At the opposite, if public health spending remain stable after 2010, the share in GDP of social protection expenditures should decrease by 0.7 and 0.6 percentage points compared to baseline in respectively 2040 and 2060. The decrease in social protection expenditures should imply low general social contribution rate compared to baseline. The low general social contribution rate should reduce the crowding-out effect and explain the improvement of GDP per capita observed in scenarios 4 and 5.

### 4.4.4 The welfare impacts of health spending

The simulations outcomes outlined in Tables 4.7, 4.8, 4.9, 4.10, 4.11 and 4.12 underline that the effects of the future increase in health spending (including the increase in life expectancy, the labor efficiency improvement, the economic growth, the fiscal burden, the transfers allocated by social security, etc) are numerous, should vary over time and impact differently all generations. Appreciating the economic effects of health spending by considering all effects, all periods and all generations is then not always easy. To tackle this difficulty, we focus on welfare variation induced by the different evolutions of health spending in the coming decades. Indeed, all economic effects of health spending affect directly the welfare of each generation at each period. Assessing the intertemporal welfare evolution of each generation should then allow to analyze the overall intertemporal impacts of health spending on each cohort.

As described in Section 4.1.3, health affect the individual welfare through three channels. The first one is the direct link between health status and the instantaneous felicity. The second channel occurs through the link between state of health and individual survival rates. This channel implies that better health status offers additional periods of utility to each generation. Finally, the third channel occurs through the link between health status and labor productivity. Indeed, better health status should improve labor productivity, labor remuneration and available income. The rise in available income allows to consume more and make more out-of-pocket expenditure on health. More consumption and out-of-pocket expenditure on health should at least enhance the instantaneous felicity and then the intertemporal utility. Thus, by assessing the intertemporal welfare of each generation, we should be able to capture all of welfare effects of the future rise in health spending and to assess the impacts of health spending over the life-cycle. By comparing the intertemporal welfare corresponding to each scenario, we should manage to identify the welfare variation induced by each scenario and compare the effect of each variant on intertemporal welfare of each cohort.

To quantify the effects of health spending on welfare, we proceed as follows. For each skill-level, at each period, we evaluate the intertemporal utility at 20 years-old by combining equations (4.9) and (4.10). We apply this method for each scenario. Thereafter, we compute the difference between intertemporal utility level provided by baseline and the one obtained in each scenario. By assessing this difference, we deduce the welfare variations resulting from the different evolution of health spending. These welfare variations are depicted in Figures 4.1, 4.2 and 4.3.

According to Figure 4.1, scenario 1 is welfare improving for each low-skill cohort having 20 years-old between 1955 and 2040. The increase in health spending expected by official forecast should enhance the intertemporal wellbeing of living and future low-skill cohorts. Moreover, it seems that financing this rise in health spending by increasing

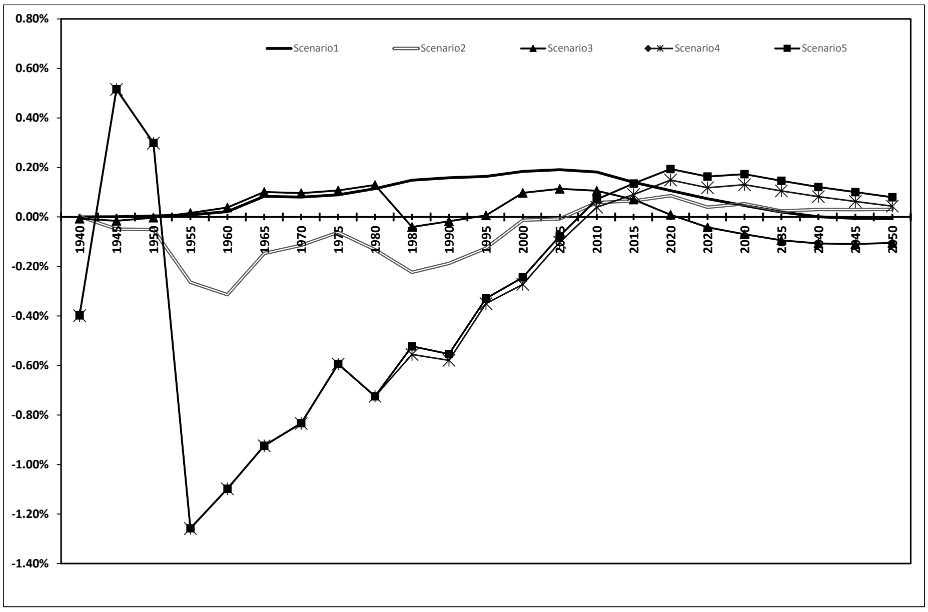
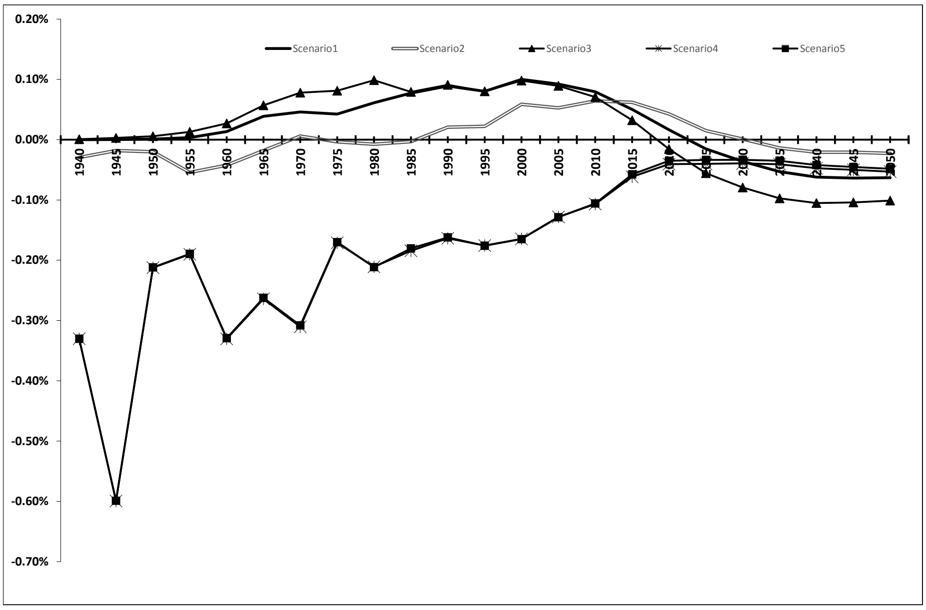



Figure 4.1: Welfare variation of LS under alternative scenarios

the general social contribution of retired people should decrease the welfare of cohorts aged 20 before 2005 (scenario 2). The decrease in available income induced by this policy should reduce the consumption of retired low-skilled and then their intertemporal utility. Financing the future increase in health spending by principally private health spending (scenarios 4 and 5) should deteriorate substantially the welfare of retired low-skilled. Indeed, the increase in flat tax (scenario 4) or the increase in out-of-pocket expenditure on health (scenario 5) should reduce the available income devote to consumption. The welfare gains resulting from the increase in private health spending should then not be enough to compensate the welfare loss arising from the decrease in consumption. That is why the welfare loss of retired low-skilled is exacerbated in scenarios 4 and 5. At opposite, financing the increase in health expenditures by rising private health spending should enhance the welfare of cohorts aged 20 after 2010. As indicated in previous Sections, the increase in private health spending should generate more economic growth compared to baseline. More economic growth increases available income, consumptions and out-of-pocket expenditure on health. That is why, for these cohorts, the welfare gains resulting from the increase in private health spending should be enough to compensate the welfare loss arising from the decrease in available income.

Figure 4.2: Welfare variation of MS under alternative scenarios

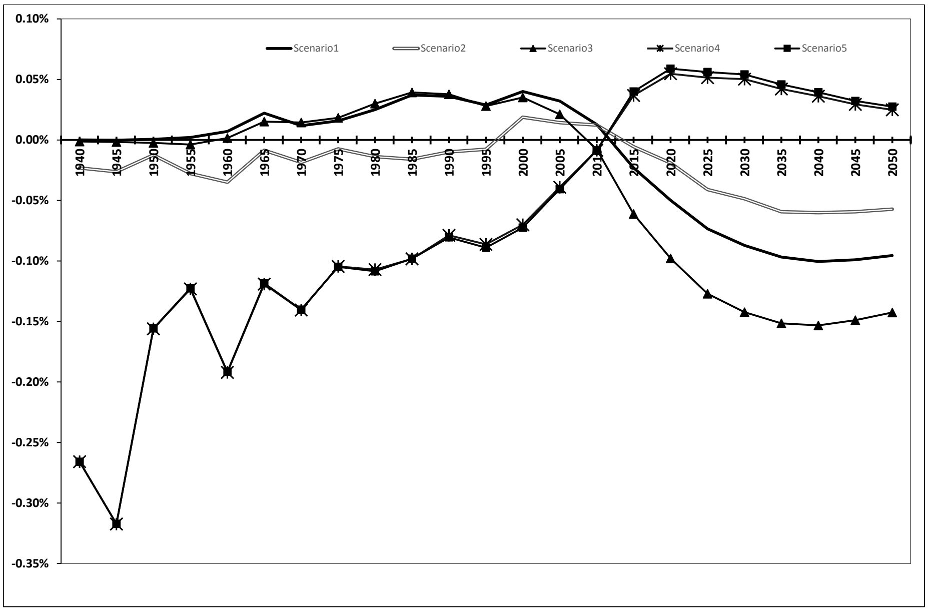



By focusing on the intertemporal welfare of medium- and high-skill cohorts, Figures 4.2 and 4.3 suggest that, by adopting the official forecasts provided by HCAAM (2013) (scenarios 1 and 2), the future increase in health spending should deteriorate the welfare of cohorts aged 20 after 2010. It seems that, in these scenarios, the crowding-out effect resulting from the increase in public health spending should imply a welfare loss annihilating the welfare gains arising from the health improvement. The welfare loss is exacerbated if the increase in health spending is mainly determined by the rise in public health spending (scenario 3).

In sum, it appears that, first, each scenario affects the intertemporal welfare of each skill. Second, the welfare effects of each scenario vary across skill-level. Third, the impacts of each scenario on welfare differs also across generations.

Figure 4.3: Welfare variation of HS under alternative scenarios




## 4.5 The long term benefits resulting from health spending in France

Section 4.4 indicates that economic benefits resulting from the future increase in health spending as forecasted by HCAAM (2013) should be very small. At the same time, it would be logical to think that these small benefits are consistent with the slight increase in health spending expected by HCAAM (2013). Simulating other scenarios with much more health spending in the coming decades should then provide much more optimistic results on economic benefits of health spending in French economy. However, assuming a much more increase in health spending in future is not very realistic as the willingness of French administration is to slow down the evolution of French health spending. Because of this background, providing economic policy recommendations based on scenario in which health spending increase significantly should have no sense. This is the reason why we do not adopt this strategy.

The retained strategy consists here to investigate the economic benefits resulting from the significant increase in health spending recorded in France during the last decades. The share in GDP of total health spending increased from 5.3% in 1945 to 10.24% in 2010. For that purpose, we develop two counterfactual scenarios in which the evolution of health spending during the last decades differs to the one informed in official statistics. In the first counterfactual scenario (referred to below as CTF1), we assume that share in GDP of public and private health spending, and total health expenditures remains stable after 1970. Namely, the share in GDP of public and private health spending, and total health expenditures can never exceed respectively 4%, 1.1% and 6% after 1970. It implies that share in GDP of out-of-pocket expenditure on health can never exceed 0.9% after 1970. Comparison between baseline and CTF1 should then provide a measure of economic benefits resulting from the past increase in health spending in France. In the second counterfactual scenario (referred to below as CTF2), we assume that total health spending evolve as indicated in official statistics until 2010 and follow the official forecasts like in scenario 1 (see Section 4.4) until 2100. However, in CTF2, the shares in GDP of public and private health spending remain at their 1970 level. In other words, in CTF2, only out-of-pocket expenditure on health drive the increase in total health expenditures over time. Comparison between baseline and CTF2 should then provide an assess of long term effect of public and private health spending in France. Like in Section 4.4, we also develop a counterfactual scenario *bis* for each scenario in which demographic bloc is totally exogenous. Comparison between CTF and CTF *bis* should allow to isolate the demographic and economic effects of health spending in long term.

Table 4.13 briefly describes the evolution of each component of health spending in France under each counterfactual scenario from 1970. As expected, public health spending appears much more lower over time in CTF 1 and CTF2 than in baseline. Even if general social contribution rate varies to ensure the balance of public health insurance budget at each period, the decrease in public health spending allows to reduce significantly the weight of this part of health expenditures in France. Note that like in previous Section, our results are robust to demographic assumptions.

Table 4.13: Health spending under counterfactual scenarios (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Total health expenditures (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 6.08% | 7.05% | 8.48% | 10.71% | 10.24% | 10.73% | 10.73% | 10.73% | 10.72% | 10.72% |
| - CTF 1 (a) | 0.00% | -0.95% | -2.40% | -4.66% | -4.20% | -4.72% | -4.74% | -4.75% | -4.74% | -4.72% |
| - CTF 1 bis (a) | 0.00% | -0.96% | -2.40% | -4.64% | -4.17% | -4.67% | -4.68% | -4.69% | -4.69% | -4.68% |
| - CTF 2 (a) | 0.00% | 0.05% | 0.03% | -0.05% | -0.08% | 0.25% | 1.14% | 1.92% | 2.31% | 2.33% |
| - CTF 2 bis (a) | 0.00% | 0.05% | 0.03% | -0.05% | -0.08% | 0.25% | 1.13% | 1.90% | 2.28% | 2.29% |
| ***Public health spending (in % of GDP)*** | | | | | | | | | | |
| Expenditures | | | | | | | | | | |
| - Baseline | 4.1% | 5.2% | 5.8% | 7.3% | 7.7% | 8.3% | 8.3% | 8.3% | 8.3% | 8.3% |
| - CTF 1 (a) | 0.0% | -1.1% | -1.7% | -3.3% | -3.7% | -4.3% | -4.3% | -4.3% | -4.3% | -4.3% |
| - CTF 1 bis (a) | 0.0% | -1.1% | -1.7% | -3.3% | -3.7% | -4.2% | -4.3% | -4.3% | -4.3% | -4.3% |
| - CTF 2 (a) | 0.0% | -1.1% | -1.7% | -3.3% | -3.7% | -4.2% | -4.2% | -4.2% | -4.2% | -4.2% |
| - CTF 2 bis (a) | 0.0% | -1.1% | -1.7% | -3.3% | -3.7% | -4.2% | -4.2% | -4.2% | -4.3% | -4.2% |
| Financing needs | | | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 (a) | 0.0% | -1.4% | -1.9% | -1.0% | -0.9% | -1.4% | -1.4% | -1.4% | -1.4% | -1.4% |
| - CTF 1 bis (a) | 0.0% | -1.4% | -1.9% | -0.9% | -0.9% | -1.4% | -1.4% | -1.4% | -1.4% | -1.3% |
| - CTF 2 (a) | 0.0% | -1.4% | -1.9% | -1.0% | -0.9% | -1.4% | -1.3% | -1.3% | -1.3% | -1.3% |
| - CTF 2 bis (a) | 0.0% | -1.4% | -1.9% | -1.0% | -0.9% | -1.4% | -1.4% | -1.4% | -1.4% | -1.4% |
| ***Health spending reimbursed by private insurance (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 1.19% | 1.09% | 1.09% | 2.27% | 1.72% | 1.65% | 1.65% | 1.65% | 1.64% | 1.64% |
| - CTF 1 (a) | 0.0% | 0.1% | -0.4% | -1.1% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% |
| - CTF 1 bis (a) | 0.0% | 0.1% | -0.4% | -1.1% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% |
| - CTF 2 (a) | 0.0% | 0.1% | -0.4% | -1.1% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% |
| - CTF 2 bis (a) | 0.0% | 0.1% | -0.4% | -1.1% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% | -0.5% |
| ***Out-of-pocket expenditures on health (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 0.8% | 0.7% | 1.1% | -0.3% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| - CTF 1 (a) | 0.0% | 0.1% | -0.3% | -0.3% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.1% | -0.3% | -0.3% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 1.1% | 2.1% | 4.3% | 4.1% | 4.9% | 5.8% | 6.6% | 7.0% | 7.0% |
| - CTF 2 bis (a) | 0.0% | 1.1% | 2.1% | 4.3% | 4.1% | 4.9% | 5.8% | 6.6% | 7.0% | 7.0% |

Source: authors' calculation
(a) Percentage points of change compared to baseline

### 4.5.1 The small long term effects of health spending on French population

Table 4.14 suggests that the increase in health spending between 1970 and 2010 does not have a significant effect on French population evolution on the same period. More precisely, the increase in health spending has allowed to increase total French population by 0.31% in 1990 and by 0.95% in 2010. Moreover, the future stabilization in health spending after 2010 should allow to expand the size of French population by 1.03% in 2020 and 1.01% in 2040. The main effects of health spending on French population appears then in long term.

Table 4.14: French population under counterfactual scenarios (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Total population (a)*** | | | | | | | | | | |
| - Baseline (x1000) | 33 771 | 37 356 | 40 860 | 43 781 | 47 502 | 50 159 | 52 692 | 54 796 | 57 117 | 59 869 |
| - CTF 1 (e) | 0.00% | -0.02% | -0.31% | -0.67% | -0.95% | -1.03% | -1.03% | -1.01% | -0.78% | -0.61% |
| - CTF 2 (e) | 0.01% | 0.02% | 0.04% | 0.05% | 0.05% | 0.05% | 0.10% | 0.22% | 0.25% | 0.25% |
| ***Working-age population (b)*** | | | | | | | | | | |
| - Baseline (x1000) | 27 307 | 29 816 | 32 996 | 34 382 | 36 937 | 36 727 | 36 675 | 36 675 | 37 677 | 38 985 |
| - CTF 1 (e) | 0.00% | -0.01% | -0.12% | -0.24% | -0.36% | -0.32% | -0.25% | -0.20% | -0.15% | -0.12% |
| - CTF 2 (e) | 0.00% | 0.01% | 0.01% | 0.02% | 0.02% | 0.02% | 0.03% | 0.04% | 0.05% | 0.05% |
| ***Population aged 65 years-old and over*** | | | | | | | | | | |
| - Baseline (x1000) | 6 464 | 7 540 | 7 864 | 9 398 | 10 565 | 13 432 | 16 017 | 18 121 | 19 440 | 20 884 |
| - CTF 1 (e) | 0.01% | -0.06% | -1.09% | -2.22% | -3.01% | -2.98% | -2.81% | -2.64% | -2.00% | -1.52% |
| - CTF 2 (e) | 0.03% | 0.07% | 0.14% | 0.19% | 0.17% | 0.15% | 0.26% | 0.46% | 0.65% | 0.62% |
| ***Old-age-dependency ratio (c )*** | | | | | | | | | | |
| - Baseline (x1000) | 23.67% | 25.29% | 23.83% | 27.33% | 28.60% | 36.57% | 43.67% | -1.21% | 51.60% | 53.57% |
| - CTF 1 (f) | 0.00% | -0.01% | -0.23% | -0.54% | -0.76% | -0.98% | -1.12% | 0.13% | -0.96% | -0.75% |
| - CTF 2 (f) | 0.01% | 0.02% | 0.03% | 0.05% | 0.04% | 0.05% | 0.10% | 0.21% | 0.31% | 0.31% |

Source: authors' calculation
(a) Total population in model does not include population aged under 20 years-old
(b) Working-age population is composed by population aged 20 to 64 years-old
(c) Old-age-dependency ratio is given by Population aged 65 and over/Working-age population
(e) Change in percent of baseline
(f) Percentage points of change compared to baseline

The effect of health spending on working-age population is very weak contrariwise to effect on retired population. Indeed, it seems that the past increase in health spending explains 1 percentage point of expand in size of retired people in 1990. This figure attains more than 3 percentage point in 2010. From 2020 until 2060, more than 2 percentage point of expand in size of population aged 65 and over is explained by this past increase in health spending. The effect of health spending on French population aging is then significant but not substantial.

Results obtained with CTF2 show that the hypothetical evolution of French population resulting from an increase in out-of-pocket expenditures on health from 1970 until 2100, is similar to the one obtained by increasing public health spending. Differences in size of total, active and retired populations between CTF2, baseline and scenario 1 are very slight. In other words, the size and age structure of French population would not vary significantly over time if French administration keeps the share in GDP of public health spending stable after 1970 without containing the evolution of total health spending after this date. Note that health spending affects mainly the size of retired population because we establish an explicit link between health expenditures and mortality rates. That is why all counterfactual scenarios do not change significantly the size of working-age population.

Table 4.15: Life expectancy of active population under counterfactual scenarios (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***High skilled*** | | | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | | | |
| - Baseline (years) | 58.6 | 60.0 | 61.9 | 64.0 | 65.6 | 66.8 | 67.8 | 68.8 | 70.6 | 70.6 |
| - CTF 1 (a) | 0.0 | -2.8 | -6.0 | -9.3 | -7.6 | -7.6 | -6.9 | -6.2 | -5.1 | -5.1 |
| - CTF 2 (a) | 0.0 | 0.4 | 0.5 | 0.4 | 0.3 | 0.8 | 1.7 | 2.2 | 2.1 | 2.1 |
| Life expectancy at 60 years-old | | | | | | | | | | |
| - Baseline (years) | 21.9 | 23.1 | 24.7 | 26.3 | 27.5 | 28.5 | 29.3 | 30.1 | 31.6 | 31.6 |
| - CTF 1 (a) | 0.0 | -1.8 | -3.9 | -6.1 | -5.1 | -5.1 | -4.7 | -4.3 | -3.6 | -3.6 |
| - CTF 2 (a) | 0.0 | 0.3 | 0.3 | 0.3 | 0.2 | 0.5 | 1.2 | 1.6 | 1.5 | 1.5 |
| ***Medium skilled*** | | | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | | | |
| - Baseline (years) | 56.2 | 57.7 | 59.7 | 61.9 | 63.6 | 64.9 | 66.1 | 67.2 | 69.2 | 69.2 |
| - CTF 1 (a) | 0.0 | -3.1 | -6.6 | -10.2 | -8.4 | -8.5 | -7.8 | -7.0 | -5.8 | -5.8 |
| - CTF 2 (a) | 0.0 | 0.4 | 0.5 | 0.4 | 0.3 | 0.9 | 1.9 | 2.5 | 2.4 | 2.4 |
| Life expectancy at 60 years-old | | | | | | | | | | |
| - Baseline (years) | 20.1 | 21.3 | 23.0 | 24.7 | 26.0 | 27.0 | 27.9 | 28.8 | 30.4 | 30.4 |
| - CTF 1 (a) | 0.0 | -1.9 | -4.2 | -6.5 | -5.5 | -5.7 | -5.2 | -4.7 | -4.0 | -4.0 |
| - CTF 2 (a) | 0.0 | 0.3 | 0.3 | 0.3 | 0.2 | 0.6 | 1.3 | 1.7 | 1.7 | 1.7 |
| ***Low skilled*** | | | | | | | | | | |
| Life expectancy at 20 years-old | | | | | | | | | | |
| - Baseline (years) | 53.6 | 54.9 | 57.2 | 59.7 | 61.6 | 63.1 | 64.4 | 65.7 | 67.9 | 67.9 |
| - CTF 1 (a) | 0.0 | -3.1 | -7.6 | -11.9 | -9.8 | -9.9 | -9.1 | -8.2 | -6.8 | -6.8 |
| - CTF 2 (a) | 0.0 | 0.5 | 0.6 | 0.5 | 0.4 | 1.0 | 2.3 | 3.0 | 2.8 | 2.8 |
| Life expectancy at 60 years-old | | | | | | | | | | |
| - Baseline (years) | 18.6 | 19.6 | 21.6 | 23.4 | 24.7 | 25.8 | 26.8 | 27.8 | 29.5 | 29.5 |
| - CTF 1 (a) | 0.0 | -1.7 | -4.5 | -7.0 | -6.0 | -6.2 | -5.7 | -5.2 | -4.4 | -4.4 |
| - CTF 2 (a) | 0.0 | 0.3 | 0.3 | 0.3 | 0.2 | 0.7 | 1.4 | 1.9 | 1.8 | 1.8 |

Source: authors' calculation
(a) Change in number of months compared to baseline

To appreciate the life gains resulting from the past increase in health spending, we indicate in Table 4.15 the evolution of life expectancy under each counterfactual scenario. It appears that the expand in lifetime allowed by the past increase in health expenditures is not really substantial. In average, the life gains resulting from the past increase in health spending never exceed 1 year and 8 months for respectively young and retired populations at each period. These results suggest that health spending is not the only driver of French population aging observed in last decades and expected in coming years.

### 4.5.2 Health spending and crowding-out effect in France

Previously, Section 4.4 highlights the crowding-out effect generated by public health spending on French economy. This crowding-out effect is confirmed by counterfactual scenarios as indicated in Table 4.16. Indeed, results obtained with CTF1 in Table 4.16 indicate that lower health spending from 1970 would generate more than 1% and 2.5% additional GDP per capita compared to baseline in respectively 2000 and 2010. The potential economic growth resulting from this low health spending level should induce more than 3% additional GDP per capita at each period compared to baseline after 2010.

The additional potential economic growth recorded in CTF1 is not the result of improvement in human capital in health form. At the opposite, the stabilization of health spending after 1970 affects negatively and deeply the human capital in health form compared to baseline. By maintaining health spending at its 1970 level, the average efficient labor per worker decreases by more than 9% compared to baseline at each period from 2000 to 2100. However, this negative evolution of human capital in health form over time has no detrimental effect on economic growth in long term. In addition, lower level in health spending would allow to increase the available income compared to baseline according to Table 4.17. It appears that the average net wage of working-age population would improve by more than 8% per period compared to baseline if share in GDP of total health spending remains stable since 1970. All of these features suggest that potential economic growth resulting form the decrease in

Table 4.16: Main macroeconomic aggregates under counterfactual scenarios (1) (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***GDP per capita (base 2010 = 1)*** | | | | | | | | | | |
| - Baseline | 0.50 | 0.59 | 0.65 | 0.76 | 1.00 | 1.12 | 1.21 | 1.33 | 1.63 | 2.44 |
| - CTF 1 (b) | 0.0% | 0.4% | 0.8% | 1.6% | 2.45% | 3.07% | 3.37% | 3.54% | 3.45% | 3.18% |
| - CTF 1 bis (b) | 0.0% | 0.7% | 1.2% | 1.9% | 2.43% | 2.78% | 2.90% | 2.96% | 3.00% | 2.97% |
| - CTF 2 (b) | 0.0% | 1.6% | 2.5% | 3.1% | 2.98% | 3.95% | 4.37% | 4.44% | 4.27% | 4.14% |
| - CTF 2 bis (b) | 0.0% | 1.6% | 2.5% | 3.1% | 2.97% | 3.91% | 4.30% | 4.41% | 4.34% | 4.23% |
| ***Tax rate on wages (a)*** | | | | | | | | | | |
| - Baseline | 2.9% | 5.7% | 5.4% | 4.4% | 14.2% | 13.3% | 13.7% | 13.8% | 13.5% | 13.6% |
| - CTF 1 (c) | 0.00% | 0.0% | 0.0% | 0.0% | -0.11% | -0.1% | -0.1% | -0.1% | 0.0% | 0.1% |
| - CTF 1 bis (c) | 0.00% | 0.0% | 0.0% | 0.1% | 0.10% | 0.1% | 0.1% | 0.2% | 0.2% | 0.2% |
| - CTF 2 (c) | 0.00% | 0.0% | 0.0% | 0.1% | 0.18% | 0.1% | 0.0% | 0.0% | 0.2% | 0.2% |
| - CTF 2 bis (c) | 0.00% | 0.0% | 0.0% | 0.0% | 0.17% | 0.1% | 0.0% | 0.0% | 0.1% | 0.1% |
| ***Average human capital in education form per worker (base 2010 = 1)*** | | | | | | | | | | |
| - Baseline | 0.187 | 0.298 | 0.476 | 0.732 | 1.000 | 1.173 | 1.294 | 1.334 | 1.338 | 1.339 |
| - CTF 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Average experience per worker (base 2010 = 1)*** | | | | | | | | | | |
| - Baseline | 0.811 | 0.796 | 0.856 | 0.946 | 1.000 | 1.005 | 0.993 | 0.992 | 1.000 | 1.000 |
| - CTF 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Average efficient labor per worker (base 2010 = 1)*** | | | | | | | | | | |
| - Baseline | 0.389 | 0.448 | 0.530 | 0.746 | 1.000 | 1.187 | 1.468 | 1.805 | 2.706 | 2.711 |
| - CTF 1 (b) | 0.0% | -2.6% | -5.8% | -9.6% | -8.6% | -9.4% | -9.3% | -9.3% | -9.2% | -9.2% |
| - CTF 1 bis (b) | 0.0% | -0.1% | 0.1% | -0.3% | -0.1% | -0.1% | -0.2% | -0.2% | -0.2% | 0.0% |
| - CTF 2 (b) | 0.0% | 0.4% | 0.5% | 0.4% | 0.3% | 1.1% | 2.6% | 3.8% | 4.3% | 4.3% |
| - CTF 2 bis (b) | 0.0% | -0.1% | 0.1% | -0.3% | -0.1% | -0.1% | -0.2% | -0.2% | -0.2% | 0.0% |

Source: authors' calculation
(a) Tax rate on wages excludes social contributions and csg, in %
(b) Change in percent of baseline
(c ) Percentage points of change compared to baseline

health spending occurs through the crowding-out effect reduction.

Table 4.17: Main macroeconomic aggregates under counterfactual scenarios (2) (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Skill premium (secondary school - in %)*** | | | | | | | | | | |
| - Baseline | 379.61% | 252.37% | 182.66% | 143.83% | 173.84% | 170.48% | 171.54% | 171.41% | 171.38% | 171.33% |
| - CTF 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Experience premium (20 years of experience - in %)*** | | | | | | | | | | |
| - Baseline | 30.84% | 30.75% | 30.07% | 31.09% | 32.84% | 32.68% | 32.28% | 32.30% | 32.35% | 32.11% |
| - CTF 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| ***Average wage for 15-65 years (base 2010 = 1)*** | | | | | | | | | | |
| - Baseline | 0.484 | 0.530 | 0.623 | 0.887 | 1.000 | 1.241 | 1.342 | 1.537 | 1.933 | 2.953 |
| - CTF 1 (b) | 0.0% | 2.0% | 3.0% | 6.0% | 8.2% | 9.8% | 10.1% | 10.3% | 10.2% | 10.0% |
| - CTF 1 bis (b) | 0.0% | 2.4% | 3.7% | 6.9% | 9.0% | 10.3% | 10.3% | 10.4% | 10.3% | 10.2% |
| - CTF 2 (b) | 0.0% | 3.3% | 5.3% | 8.3% | 9.6% | 11.7% | 12.2% | 12.4% | 12.0% | 11.8% |
| - CTF 2 bis (b) | 0.0% | 3.3% | 5.2% | 8.3% | 9.5% | 11.6% | 12.0% | 12.1% | 11.9% | 11.7% |
| ***Return on capital (annual real interest rate - in %)*** | | | | | | | | | | |
| - Baseline | 5.96% | 4.51% | 4.69% | 3.75% | 3.26% | 3.58% | 4.09% | 4.24% | 4.41% | 4.54% |
| - CTF 1 (b) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 1 bis (b) | 0.0% | 0.0% | -0.1% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 2 (b) | 0.0% | -0.2% | -0.3% | -0.2% | -0.2% | -0.2% | -0.3% | -0.3% | -0.3% | -0.3% |
| - CTF 2 bis (b) | 0.0% | -0.2% | -0.3% | -0.2% | -0.2% | -0.2% | -0.3% | -0.3% | -0.3% | -0.3% |

Source: authors' calculation
(b) Change in percent of baseline
(c ) Percentage points of change compared to baseline

Nonetheless, results provided by CTF2 suggest that health spending could affect positively economic growth in long term if the crowding-out effect is minimized. Remind that in CTF2 we assume that evolution of share in GDP of total health spending follows (i) official statistics until 2010 and (ii) official forecast until 2100. However the increase in health spending is mainly driven by the expand in out-of-pocket expenditure on health in CTF2. Under these features, it appears that health spending are able to create more economic growth than in baseline and CTF1. GDP per capita in CTF2 is 2.5% higher than the one in baseline in 1990. From 2020 until 2100, the increase in out-of-pocket expenditure on health allows to increase the GDP per capita by about 4% per period compared to baseline.

In fact, in CTF2, the increase in out-of-pocket expenditure on health improves significantly human capital in health form without reducing the available income and then saving. The increase in out-of-pocket expenditure on health allows to expand the average efficient labor per worker by more than 2% per period compared to baseline after 2030 (see Table 4.16). At the same time, the average net wage of working-age population increases by more than 11% per period compared to baseline after 2030. The increase in available income allows to save more and expand physical capital stock over time. This situation implies a decrease in real interest rate by approximately 0.2 percentage point compared to baseline from 1980. All of these mechanisms generate more economic growth than in baseline scenario. Note that the increase in out-of-pocket expenditure on health in CTF2 does not involve any change in human capital in educational and experience forms and does not modify their remunerations. That is why we think that the supplementary economic growth recorded in CTF2 is the result of crowding-out effect minimization allowed by out-of-pocket expenditure on health.

These results suggest that the long run economic effects of health spending depend primarily on the type of health spending. It appears that labor productivity gains obtained by increasing the public health spending are annihilated by the crowding-out effect arising from these expenditures. That is why the public health spending fail to boost the economic growth and could have a negative consequences on economic performance. At the opposite, the increase in private health spending generate labor productivity gains without inducing a crowding-out effect. That is why these health expenditures manage to improve the GDP per capita compared to baseline.

### 4.5.3 Less health spending for less Social Security expenditures

As expected, Table 4.18 indicates that share in GDP of Social Security expenditures in CTF1 and CTF2 decreases significantly over time compared to baseline. In average, in CTF1 and CTF2, the share in GDP of social protection expenditures drops by more than 3 percentage point per period compared to baseline from 2000. In 2100, this figure should attain more than 4 percentage point compared to baseline.

Even if public health spending decrease, the share in GDP of social contribution

Table 4.18: Social protection budget under counterfactual scenarios (1) (1970-2100)

| | *1970* | *1980* | *1990* | *2000* | *2010* | *2020* | *2030* | *2040* | *2060* | *2100* |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Social protection expenditures (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 14.83% | 21.33% | 22.90% | 25.63% | 27.64% | 28.62% | 28.41% | 28.32% | 27.88% | 27.89% |
| - CTF 1 (a) | 0.00% | -1.19% | -1.87% | -3.62% | -4.23% | -4.88% | -4.86% | -4.84% | -4.68% | -4.57% |
| - CTF 1 bis (a) | 0.00% | -1.24% | -1.86% | -3.50% | -3.98% | -4.56% | -4.52% | -4.49% | -4.42% | -4.40% |
| - CTF 2 (a) | 0.00% | -1.33% | -2.00% | -3.63% | -3.94% | -4.60% | -4.61% | -4.58% | -4.43% | -4.39% |
| - CTF 2 bis (a) | 0.00% | -1.33% | -2.01% | -3.64% | -3.95% | -4.61% | -4.62% | -4.61% | -4.49% | -4.46% |
| ***Social contributions (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 12.78% | 18.35% | 19.03% | 18.78% | 19.35% | 19.76% | 19.60% | 19.56% | 19.52% | 19.52% |
| - CTF 1 (a) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| - CTF 1 bis (a) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| - CTF 2 (a) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| - CTF 2 bis (a) | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| ***General Social Contribution (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 0.00% | 0.00% | 0.00% | 4.70% | 5.37% | 5.60% | 5.58% | 5.58% | 5.57% | 5.57% |
| - CTF 1 (a) | 0.00% | 0.00% | 0.00% | -3.29% | -3.72% | -4.32% | -4.34% | -4.34% | -4.33% | -4.31% |
| - CTF 1 bis (a) | 0.00% | 0.00% | 0.00% | -3.28% | -3.69% | -4.28% | -4.28% | -4.28% | -4.28% | -4.28% |
| - CTF 2 (a) | 0.00% | 0.00% | 0.00% | -3.30% | -3.72% | -4.28% | -4.29% | -4.29% | -4.28% | -4.28% |
| - CTF 2 bis (a) | 0.00% | 0.00% | 0.00% | -3.30% | -3.72% | -4.28% | -4.29% | -4.29% | -4.29% | -4.29% |
| ***Financing needs (in % of GDP)*** | | | | | | | | | | |
| - Baseline | 0.00% | 0.00% | 0.00% | 0.00% | -0.70% | -1.00% | -1.00% | -0.90% | -0.60% | -0.60% |
| - CTF 1 (a) | 0.00% | -1.50% | -2.10% | -1.32% | -1.48% | -1.99% | -1.96% | -1.93% | -1.79% | -1.67% |
| - CTF 1 bis (a) | 0.00% | -1.55% | -2.10% | -1.20% | -1.22% | -1.67% | -1.62% | -1.58% | -1.53% | -1.50% |
| - CTF 2 (a) | 0.00% | -1.67% | -2.27% | -1.33% | -1.22% | -1.71% | -1.71% | -1.67% | -1.54% | -1.49% |
| - CTF 2 bis (a) | 0.00% | -1.67% | -2.28% | -1.34% | -1.23% | -1.72% | -1.72% | -1.70% | -1.61% | -1.56% |
| Unemployment (in % of GDP) | | | | | | | | | | |
| Expenditures | | | | | | | | | | |
| - Baseline | 0.8% | 2.2% | 2.3% | 2.0% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% | 1.9% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | | | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Social Assistance (in % of GDP) | | | | | | | | | | |
| Expenditures | | | | | | | | | | |
| - Baseline | 0.1% | 0.1% | 0.2% | 0.4% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% | 0.6% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | | | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

Source: authors' calculation
(a) Percentage points of change compared to baseline

Table 4.19: Social protection budget under counterfactual scenarios (2) (1970-2100)

| | ***1970*** | ***1980*** | ***1990*** | ***2000*** | ***2010*** | ***2020*** | ***2030*** | ***2040*** | ***2060*** | ***2100*** |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Retirement (in % of GDP)*** | | | | | | | | | | |
| Expenditures | | | | | | | | | | |
| - Baseline | 7.8% | 10.3% | 11.2% | 12.3% | 13.8% | 14.2% | 14.0% | 13.9% | 13.5% | 13.5% |
| - CTF 1 (a) | 0.0% | 0.0% | -0.1% | -0.3% | -0.4% | -0.5% | -0.4% | -0.4% | -0.2% | -0.1% |
| - CTF 1 bis (a) | 0.0% | 0.0% | -0.1% | -0.1% | -0.2% | -0.2% | -0.1% | -0.1% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | -0.2% | -0.2% | -0.1% | -0.1% | -0.1% | -0.1% | 0.1% | 0.1% |
| - CTF 2 bis (a) | 0.0% | 0.0% | -0.2% | -0.2% | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% |
| Financing needs | | | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | -0.7% | -1.0% | -1.0% | -0.9% | -0.6% | -0.6% |
| - CTF 1 (a) | 0.0% | 0.0% | -0.1% | -0.3% | -0.4% | -0.5% | -0.4% | -0.4% | -0.2% | -0.1% |
| - CTF 1 bis (a) | 0.0% | 0.0% | -0.1% | -0.2% | -0.2% | -0.2% | -0.1% | -0.1% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | -0.2% | -0.2% | -0.1% | -0.1% | -0.1% | -0.1% | 0.1% | 0.1% |
| - CTF 2 bis (a) | 0.0% | 0.0% | -0.2% | -0.2% | -0.1% | -0.1% | -0.1% | -0.1% | 0.0% | 0.0% |
| ***Family-Housing (in % of GDP)*** | | | | | | | | | | |
| Family expenditures | | | | | | | | | | |
| - Baseline | 2.0% | 3.0% | 2.6% | 2.7% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% | 2.8% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| Housing expenditures | | | | | | | | | | |
| - Baseline | 0.2% | 0.5% | 0.8% | 0.9% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% | 0.8% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| Financing needs | | | | | | | | | | |
| - Baseline | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| - CTF 1 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 1 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 2 (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |
| - CTF 2 bis (a) | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | -0.1% | -0.1% | -0.1% | -0.1% | -0.1% |

Source: authors' calculation
(a) Percentage points of change compared to baseline

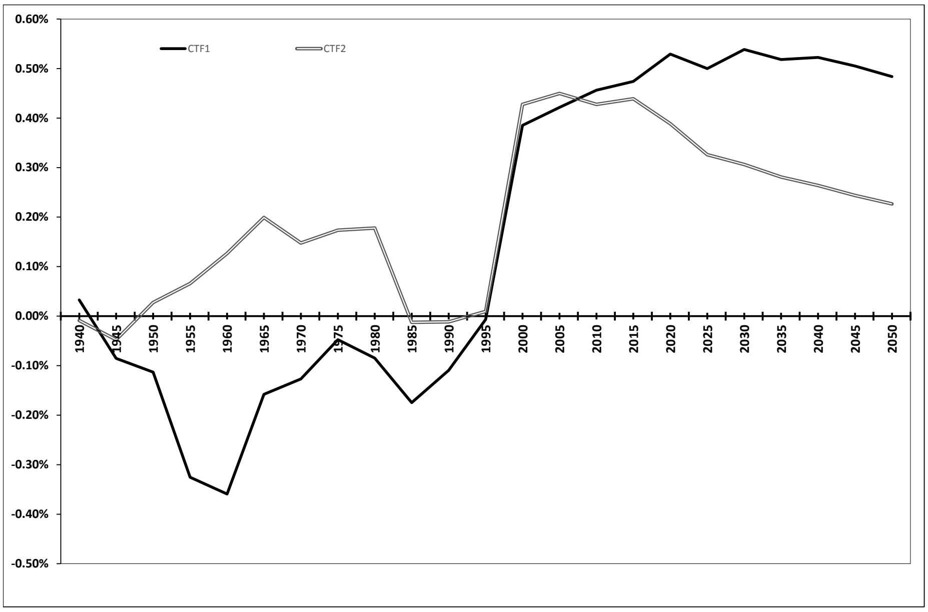
 

does not vary in CTF1 and CTF2. However, the share in GDP of general social contribution decreases by more than 3 percentage point per period compared to baseline from 2000 in CTF1 and CTF2. Social Security deficit diminishes also over time in CTF1 and CTF2. In average, the share in GDP of social protection deficit is reduced by more than 1 percentage point per period compared to baseline.

The deficit reduction of Social Security is mainly driven by the decrease in health spending because the other posts of social protection budget do not vary in CTF1 and CTF2. The shares in GDP of unemployment, social assistance, family and housing expenditures do not change with public health spending stabilization after 1970. The share in GDP of retirement expenditures decreases slightly with public health expenditures stabilization. However, as indicated in Table 4.19, the reduction in retirement expenditures is not enough to amplify the decrease in social protection deficit.

### 4.5.4 The welfare gains resulting from health spending

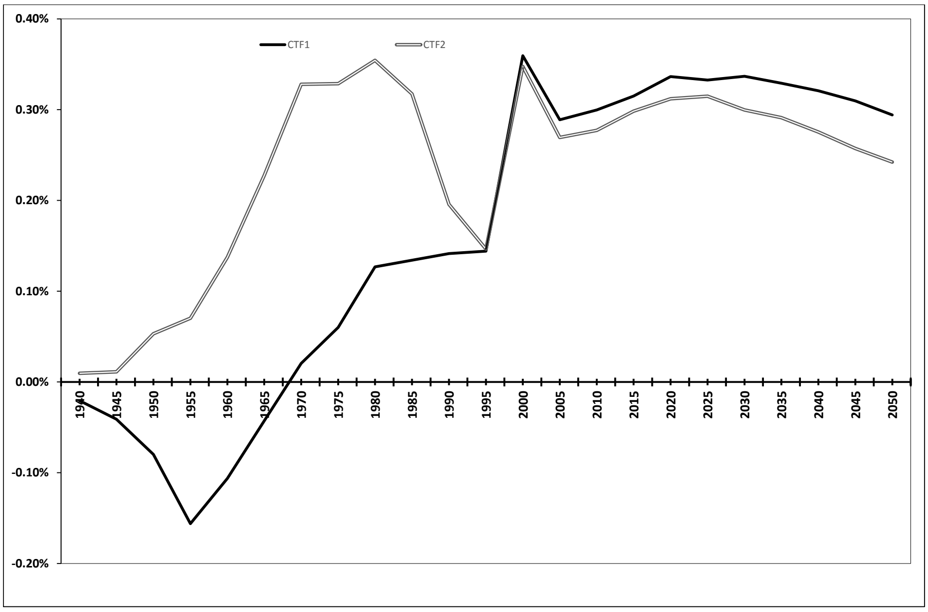
Figure 4.4: Welfare variation of LS under counterfactual scenarios



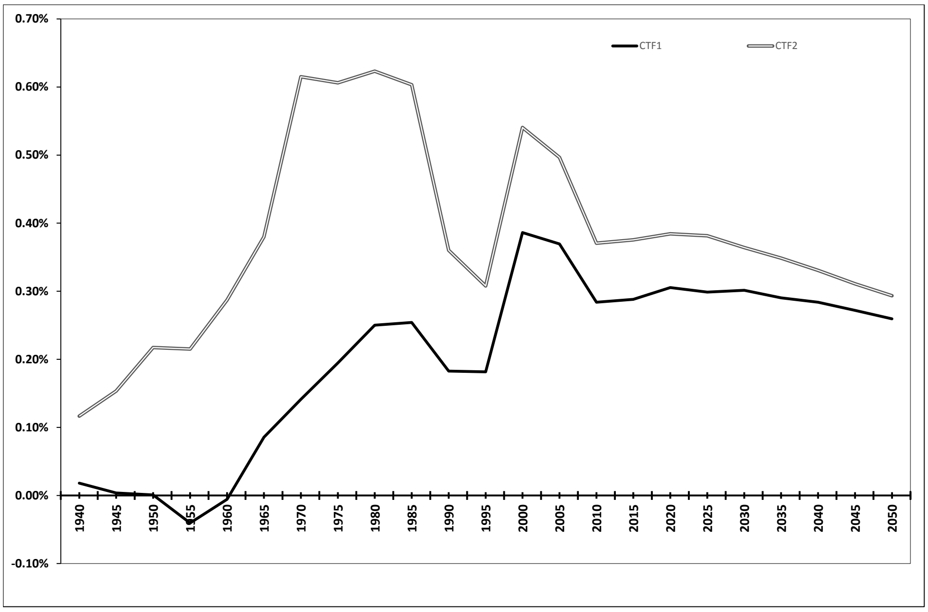
To evaluate the welfare variation resulting from each counterfactual scenario, we proceed as in Section 4.4.4 and outline the results in Figures 4.4, 4.5 and 4.6. It appears that low-skill cohorts aged 20 before 1995 are the main beneficiaries of the past increase in public health spending. Indeed, according to results provided by CTF1, without any increase in public health expenditures, these cohorts would have experienced a welfare loss. This finding is also valid for medium-skilled cohorts aged 20 before 1970. Public health spending improve the welfare of cohorts aged 20 before 1970 by reducing the mortality rates and offering additional utility periods. The effects of public health spending on old-cohorts are slight. This result suggest that the additional utility resulting from the decrease in mortality rates should not improve significantly the intertemporal welfare near the end of life-cycle.

Figure 4.5: Welfare variation of MS under counterfactual scenarios




However, its seems that maintaining the health spending at its 1970 level would have been a welfare improving policy for young cohorts, namely generations aged 20 after 1970. Indeed, according to results obtained with CTF1, the health spending stabilization after 1970 would enhance the welfare of LS, MS and HS aged 20 after respectively 1995, 1970 and 1960. This welfare improvement is permanent and occurs on future cohorts aged 20 after 2050. According to this result, after 1970, the welfare gains resulting from the increase in GDP per capita should offset the welfare loss arising from the decrease in health spending. That is why CTF1 is welfare improving for cohorts aged 20 after 1970.

Figure 4.6: Welfare variation of HS under counterfactual scenarios




Results provided by CTF2 underline the ability of out-of-pocket to improve the welfare of young and old cohorts whatever their skill-level. Indeed, it seems that if increase in health spending after 1970 was mainly driven by the rise in out-of-pocket expenditure on health, then cohorts aged 20 before 1990 whatever their educational attainment would have experienced a welfare improvement over their life cycle. This result underlines the welfare gains resulting from both (i) the increase in GDP per capita and (ii) the health improvement. There is no welfare loss induced by the health deterioration in CTF2. Moreover, it seems that welfare improvement arising from the stabilization of health spending after 1970 is higher for low- and medium-skilled cohorts aged 20 after 1995 than the one resulting from the rise in out-of-pocket expenditure on health.

## 4.6 Conclusion

The economic consequences of population aging are well established in economic literature. However, the magnitude of economic changes resulting from this demographic mutation is uncertain because the evolution of labor productivity is unknown. By considering the simultaneous effects of education, experience and health on labor productivity, we attempt to analyze the future evolution of labor productivity by developing an applied general equilibrium model with overlapping generations. The simulation outcomes provided by our applied general equilibrium model confirm the negative effect of French population aging on Social Security budget. It appears that due to French population aging, the retirement and health expenditures should continue to grow and increase the public deficit. Even if the increase in health spending should deteriorate the Social Security budget, the future rise in health expenditures should induce three positive effects on French economy. These positive impacts are the expand in life expectancy, the welfare improvement and the labor efficiency enhancement.

Unfortunately, the lifetime gains resulting from the future increase in health spending should not be very substantial and just generate a slight expand in size of retired population. The welfare improvement obtained with the future rise in health expenditures should especially affect the old cohorts but should also deteriorate the wellbeing of young cohorts. The labor efficiency enhancement resulting from the future rise in health spending are substantial but the crowding-out effect generated by public health expenditures should annihilate the productivity gains allowed by this increase in health spending. Nonetheless, the crowding-out effect is minimized if the increase in total health spending is mainly driven by the rise in out-of-pocket expenditure on health over time. The effects of the past increase in health expenditures on French economy are established by undertaking two counterfactual simulations. The results obtained with these counterfactual scenarios confirm the previous findings. Moreover, it appears that the past rise in health spending contributes to French population aging but its contribution is not very substantial.

Thus, this Chapter shows that channels through which health spending affect the economy are numerous but the size of economic effects of health expenditures depends mainly on how these expenditures are financed. Neoclassical features of our AGEM-OLG provide outcomes suggesting to favor out-of-pocket expenditure on health. At the opposite, economic literatures on moral hazard and adverse selection advocate to socialize more the health spending. Including moral hazard and adverse selection problems in an AGEM-OLG devoted to study the effects of health spending on mortality, welfare and labor productivity seems then necessary to provide an accurate measure on economic impacts of health expenditures. This issue is included in our research agenda.

# General conclusion

Analyzing other potential channels through which health spending can affect labor productivity and assessing the potential benefit effects of the future increase in both life expectancy and health expenditures were the aims of this dissertation. These analysis were mainly applied on French economy where life expectancy and health spending increase significantly during the last decades.

Theoretical analysis undertaken in the first Chapter reveals that even if households make health expenditures to improve only their life quality, these health spending are also able to generate a positive externality affecting positively labor efficiency and then labor productivity. On one side, this first potential channel through which health spending could impact labor productivity contrasts with the traditional one assuming an explicit direct link between health expenditures and labor productivity. On the other side, this theoretical result provides an additional support to Hall and Jones (2007) findings that suggest to increase significantly the weight of health spending in economy to improve the social welfare. Indeed, by linking our theoretical result with the one highlighted by Hall and Jones (2007), it seems that devoting more resources to health expenditures in order to improve the intertemporal utility as suggested by Hall and Jones (2007) could be also an efficient way to increase resources in economy because these health spending enhance in parallel labor productivity and then wealth production.

In France, these health expenditures are composed by health spending reimbursed by public and private health insurances, and out-of-pocket expenditure on health. However, the share in total health spending of public health expenditures increases significantly over time. At the opposite, the shares in total health spending of private health spending and out-of-pocket expenditure on health remain very stable over time. The combination of the significant rise in public health spending with negative effects of population aging on French fiscal policy incites then French government to contain the evolution of public health spending. Unfortunately, the stabilization of public health expenditures could annihilate the productivity gains resulting from health spending.

Based on this observation, we investigate, in the Second Chapter of this dissertation, the ability of out-of-pocket expenditure on health to enhance labor productivity. More precisely, we attempt to verify if substituting the increase in public health spending by the rise in out-of-pocket expenditure on health could generate the same productivity gains. For that purpose, we develop a theoretical general equilibrium model with two overlapping generations composed respectively by prime-age and elderly workers. At each period, we assumed that prime-age workers invest in health in order to improve his labor efficiency during old age. The out-of-pocket expenditure on health provide the amount of this health investment. Thus, by exploiting the general equilibrium framework of the model, we manage to demonstrate an explicit positive link between the out-of-pocket expenditure on health made during prime-age and labor productivity during old-age. This is how we highlight theoretically the positive effect of this minor component of total health spending on labor productivity. To determine the empirical relevance of this theoretical result, we undertake some econometric estimations by exploiting the Survey of Health, Ageing and Retirement in Europe (SHARE) database. However, the empirical results suggest that effect of out-of-pocket expenditure on health on labor productivity of elderly workers is limited and insignificant.

Results obtained in the Second Chapter of this dissertation illustrate the political issue accompanying economic challenges induced by population aging. Indeed, on one side, due to population aging, developed countries try to tackle the fiscal burden generated by this demographic mutation by adopting a fiscal policy reducing the public spending like health expenditures reimbursed by public health insurance. On the other side, some of these public spending produce some economic benefits, like productivity gains, able to diminish the threats induced by population aging. To offset the political issue, some governments of developed countries incite then their citizens to substitute public spending by private one by expecting that these latter are able to provide the same assets as public spending. Unfortunately, based on results obtained in the Second Chapter of this dissertation and by applying this political choice on health spending issue, government could annihilate the potential benefit effects resulting from public spending.

To undertake an economic policy able to meet the challenges of population aging, it is then necessary to make a trade-off between the economic policy offsetting the negative effects of population aging and the economic policy exploiting the potential positive effects induced by this demographic mutation. For that purpose, it is crucial to provide an accurate measure of potential benefit effects allowed by population aging. The second part of this dissertation was devoted to this difficult task by focusing our analysis on French economy.

In the third Chapter of this dissertation, we attempt to evaluate the productivity gains resulting from health improvement that accompanies French population aging. More precisely, we verify if these productivity gains could be able to offset the fiscal burden generated by French population aging. For that purpose, we developed a Generational Accounting Model considering the effects of changes in skill structure and health enhancement on labor productivity. Results obtained with this Generational Accounting Model reveal that productivity gains resulting from the future changes in skill structure and the future health improvement of French population should be substantial but not enough to annihilate the unsustainability of French fiscal policy. Based on this result, some fiscal adjustments like increase in tax rates or decrease in transfers should then have to apply to ensure the sustainability of fiscal policy in France.

However, results obtained with Generational Accounting Model should be interpreted carefully because, by definition, Generational Accounting Model is a partial equilibrium model. All features characterizing French economy are not taken into account in this kind of model. One of these features is the high share in GDP of public health expenditures. The share in GDP of these public health spending are besides expected to grow in the coming decades. Then, we developed an Applied General Equilibrium Model with Overlapping Generations (AGEM-OLG) in the fourth Chapter of this dissertation to measure the potential benefit effects of the future increase in both life expectancy and health expenditures allowing French population aging.

Results obtained with AGEM-OLG partially confirm those provided by Generational Accounting Model. Indeed, it appears that the future health improvement should enhance significantly labor efficiency of French workforce. This health improvement seems mainly to be driven by public health spending. However, it appears that public health expenditures should also generate a crowding-out effect on French economy and this crowding-out effect should annihilate the potential benefit effects resulting from the future increase in both life expectancy and health expenditures. Nonetheless, this crowding-out effect should be minimized if health expenditures are mainly financed by out-of-pocket expenditure on health. This last result contrasts with the one obtained in the second Chapter suggesting a limited and insignificant positive effect of out-of-pocket expenditure on health on labor productivity, and strengthens the usefulness of carry out analysis in general equilibrium framework to avoid any mismeasurement on economic consequences of health spending.

To summarize, this dissertation confirms the initial insight of Grossman (1972) suggesting a positive effect of health on labor productivity. This dissertation highlights and provides a measure of potential benefit effects of the future increase in both life expectancy and health expenditures allowing this French population aging. However, it appears that these potential benefit effects are (i) lower than those resulting from the future change in skill structure of French population, and (ii) not enough to offset the negative economic consequences induced by population aging like fiscal policy unsustainability.

Nevertheless, one should remain cautious with the scope of results obtained in this dissertation. Indeed, in the fourth Chapter of this dissertation, we assumed an exogenous educational choice while choice on skill level is not exogenous in reality.

This assumption also implies that we neglect the well-know link between educational choice and health status and then the potential link between health spending and educational attainment. Moreover, we assumed that effects of private health spending on health status are similar to those of public health expenditures because there is no substitution effects between those two expenditures. More rigorous and realistic assumptions on effects of each component of total health spending on health status are then necessary to accurate the measure on effects of public health expenditures on the French economy. Furthermore, for convenience, we did not consider the health sector as an explicit sector in the fourth Chapter of this dissertation. However, health sector could also participate in improvement of returns to health spending as labor productivity gains by making medical progress, by enhancing the medical practice, by providing better services, etc. But we neglect these potential benefit effects of health sector on labor productivity. Developing an AGEM-OLG with two sectors to include an explicit health sector seems then to be required in order to study the effects of health sector as a whole on French economy. All these issues form the lines of research that will be included in our research agenda.

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