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A Quantitative Investigation of the Laffer Curve on the Continued Work Tax
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Abstract

Social Security provisions impose a tax on continued work whereas delaying the retirement age would be favorable for the financial stability of the system. It is often argued that this tax could be removed by implementing actuarially fair schemes. However, by definition, actuarially fair benefits cannot help fund the expected Social Security deficit due to demographic changes. This paper proposes to give individuals only a *fraction* of the marginal actuarially fair incentives in case of postponed retirement. The Social Security then faces a trade off between giving enough incentives to make individuals actually delay retirement and giving little increase in Social Security provisions in order to help finance the expected deficit of the PAYG system. This trade-off is captured by a Laffer curve. This paper proposes to quantify the magnitude of this Laffer curve effect in France. Furthermore, this paper sheds light on the interaction between wealth, altruism and retirement behavior. It reveals that implementing incentives schemes would induce much more heterogeneity in retirement ages. We show that wealth favors early retirement as individuals are rich enough to bear the reduced pension associated with early retirement.

JEL Classification : H31, H55, J26

Keywords : retirement behavior and wealth, actuarially fair benefits.

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1 Introduction

As underlined by Gruber and Wise [1998], Social Security provisions, especially defined pension plans, impose strong constraints on retirement decisions. The pattern of Social Security benefits reveals the presence of an implicit tax on continued work beyond the normal retirement age: continuation in the labor force implies a reduction in the change in present discounted values of pension benefits, due to insufficient actuarial adjustment for fewer years of pension receipt. Gruber and Wise [1998] stress that this implicit tax on continued work, combined with generous replacement rates for retirees and high social security payroll (explicit) taxes for workers, gives strong incentives to leave early the labor force.

With the implicit tax on continued work and the strong decrease in benefits in case of early retirement, the current system does not accommodate the diversity in life expectancy and preferences. It is thus often argued that Social Security provisions should be actuarially neutral at the margin: additional contributions by working another year and the foregone pension due to this delayed retirement should be exactly matched by an increase in the value of the pension received over the shorter retirement period. Pension wealth then increases with continued work and compensate the worker for the lower life expectancy when she postpones retirement. Drastic Social Security reforms such as in Sweden and Italy could be viewed as an attempt to implement a pension system with an actuarially fair flavor.

However, by definition, this actuarially fair scheme does not help finance the expected Social Security deficit inherent in aging economies. Indeed, the actuarially fair provision equalizes discounted expected expenditures (increased pensions when retirement is postponed) to the additional Social Security revenue (foregone pension and contribution during the continuing working year). In the public finance view adopted in this paper, the actuarially fair scheme constitutes an upper bound on the additional pension paid to individuals who work longer. This paper proposes to give individuals only a *fraction* of the actuarially fair incentives in case of postponed retirement. As a result, if individuals are responsive to the incentive schemes by delaying retirement, they still earn an additional pension (even though this benefit is below the actuarially fair level). Besides, the Social Security gets additional revenue to help finance its expected deficit.

Under a public finance perspective, what is the suitable fraction of the actuarially fair scheme individuals should be given? It is then fairly intuitive that the Social Security faces a trade off between giving enough incentives to make individuals actually delay retirement and giving little increase in Social Security provisions in order to help finance the expected deficit of the PAYG system. This trade-off is captured by a Laffer curve. This paper proposes to quantify the magnitude of this Laffer curve effect. Our quantitative exercise relies on French data. Indeed, France is an extreme case of defined pension plans such that little freedom is left to individuals as far as retirement decisions is concerned. This paper is an attempt to assess what would happen if France were to adopt incentive schemes (i.e. a reduced implicit tax on continued work) and to what extent they can contribute to help financing expected deficits.

Beyond the public finance implications, incentives scheme could induce much more heterogeneity in retirement ages. In particular, it certainly leads to boost the role of wealth. Our model illustrates the role of wealth and incentive benefits in generating heterogeneous retirement behavior. Indeed, as a source of heterogeneity, the model takes into account only the various employment status at the end of working life, thereby discarding the heterogeneity due to other factors such as health, incomplete careers or female specific labor participation. In spite

of this streamlined heterogeneity, the interaction between incentive schemes and wealth yields very heterogeneous retirement ages.

The modeling strategy relies on two strands of the literature.

- The first one (initiated by Stock and Wise [1990] and Rust [1989], Berkovic and Stern [1991], Rust and Phelan [1997]) improves our understanding of retirement choices in life cycle models with uncertain life time and future income. Nevertheless, studies of retirement assume that capital markets are perfect, so that saving and consumption decisions are made in the background and do not affect retirement decisions.

- The second strand of the literature examines the macroeconomic impact of funded versus unfunded retirement systems (see Imrohoroglu, Imrohoroglu and Joines [1999] for a survey). This literature develops overlapping generation models with borrowing constraints and several sources of uncertainty. These heterogenous agent models allow to replicate salient features of the wealth distribution and measure the consequences of various retirement systems on the capital stock. In addition, wealth accumulation constitutes an alternative to mandatory pay-as-you go systems to smooth lifetime consumption. Wealth accumulation thereby constitutes an essential element when analyzing retirement decisions. However, these studies take retirement behavior to be fixed.

Studies of retirement and saving seem to be conducted independently of each other. This paper tries to merge both literatures by studying the interaction between wealth and retirement decisions. Recent papers tackle this issue (see Diamond and Hausman [1984] and Kahn [1988] for previous work, Coile, Diamond, Gruber and Jousten [2002], VanDerKlaauw and Wolpin [2002] and Gustman and Steinmeier [2002]). The originality of our work lies in the analysis of how altruism and social mobility across generations affects wealth decisions and retirement behavior. Along these lines, we extend Fuster [1999] and Fuster, Imrohoroglu and Imrohoroglu [2003] analysis of the role of altruism on social security reform to retirement decisions.

We show in a stationary regime that the implicit tax on continued work inherent to the current social security scheme leads the French economy to be located on the right side of the Laffer curve: from a public finance point of view, it is efficient to reduce this tax by allowing agents who decide to delay their retirement to receive additional pensions. A large fraction of the actuarial fair scheme must be given to these agents in order to maximize the expected total deficit reduction when the PAYG system is maintained. This is why the incentive scheme policy can only finance around 10% of the expected deficits. We also show that capitalizing the surplus provided by later retirements on the financial market ("mandatory funded system at the margin") improves the efficiency to this policy: a lower fraction of the actuarial fair scheme given to individuals scheme now corresponds to the maximum of the Laffer curve.

We find that retirement decision and wealth accumulation are strongly related once incentive schemes are introduced. Starting from the current homogenous retirement behaviors, we show that introducing incentives leads to much more diversity, in particular due to wealth heterogeneity across agents. Wealth favors early retirement as individuals are rich enough to bear the reduced pension associated with early retirement. Because there is some heterogeneity in social mobility across agents, altruism leads to wealth heterogeneity, thus to disparity in retirement behavior. By encouraging wealth accumulation, high altruism penalizes the incentive policy in a stationary regime.

The paper is organized as follows. After presenting the Laffer curve argument in a 2 - period model (section 2), we expose our benchmark model (section 3), its calibration (section 4) and its consistency with actual data (section 4.2). We then gauge the impact of incentive schemes on retirement behavior and Social Security budget (section 5). Section 6 proposes a quantitative evaluation of the Laffer curve on the continued work tax. Section 7 concludes.

2 A 2-period model

To shed light on the Laffer curve effect, let us consider a 2 - period overlapping generation model along the lines of Cremer and Pestieau [2003]. In the second period of length $T < 1$, agents choose their retirement age, that is a fraction $z < T$. In order to keep the model as simple as possible, we discard productivity and demographic growth. In the PAYG system, agents contribute up to a fraction θ of their wage w in order to receive a replacement rate λ, a fixed constant: in the defined contribution plan, λ does not depend on z. The early retirement age is fixed at the end of period 1. For sake of simplicity, we assume that agents do not have access to financial assets. We will then be able to stress in a very straightforward way the specific impact of the implicit tax on retirement choices.

Agents maximize the intertemporal utility function U

$$Max \qquad U(c, d, z)$$

where c is the first period consumption, d the second period consumption. Both are defined as

$$c = (1-\theta)w \tag{1}$$
$$d = (1-\theta)zw + \lambda w(T-z) \tag{2}$$

In this model, period - 2 marginal rate of substitution between consumption and leisure is

$$\frac{U'_z}{U'_d} = -(1-\theta-\lambda)w \tag{3}$$

The central planner would get an optimal marginal rate of substitution between consumption and leisure such that

$$\frac{U'_{z^*}}{U'_d} = -w \tag{4}$$

with z^* the optimum retirement age.

It can be seen from (3) and (4) that $z < z^*$: indeed, $\theta + \lambda$ constitutes a tax on continued work. The explicit tax is the payroll tax rate θ. In addition, individuals are not enticed to keep on working as λ does not compensate them for the fact that they spend less time in retirement when z increases. The budget balance of the PAYG scheme imposes

$$\lambda = \frac{\theta(1+z)}{T-z} \tag{5}$$

We can restore the first best marginal rate of substitution between consumption and retirement age (equation (4)) by indexing the replacement rate on the number of working years, thereby introducing an actuarially fair structure into retirement provisions. Let λ_1 denote the

minimum replacement rate given to individuals who retire at the very beginning of period 2 ($z = 0$). As soon as $z > 0$, agents defer retirement, which increases their retirement pension. Period 2 replacement rate is denoted $\lambda_2^*(z)$. The replacement rate λ then equals $\lambda_1 + \lambda_2^*(z)$. The budget balance of the PAYG system imposes

$$\lambda_1 = \frac{\theta}{T} \tag{6}$$

Using (5), $\lambda_2^*(z)$ is such that

$$\lambda_2^*(z) = \frac{z(\theta + \lambda_1)}{T - z} \tag{7}$$

Equation (7) states that the additional pension in case of delayed retirement is matched by the non - payment of retirement pensions and payroll taxes paid by agents who continue working. As a result, period - 2 household's budget constraint is such that

$$d = zw + \lambda_1 wT$$

The optimal marginal rate of substitution between consumption and retirement age is then restored. Furthermore, the PAYG budget constraint is satisfied.

This paper proposes to give individuals who are willing to defer retirement only a *fraction* $(1 - \tau)$ of the actuarially fair bonus $\lambda_2^*(z)$:

$$\lambda_2 = (1 - \tau)\lambda_2^* \qquad 0 \leq \tau \leq 1 \tag{8}$$

Household's period - 2 budget constraint becomes

$$d = (1 - \tau(\theta + \lambda_1))wz + \lambda_1 wT$$

The marginal rate of substitution between consumption and retirement age equals

$$\frac{U_z'}{U_d'} = -(1 - \tau(\theta + \lambda_1))w \tag{9}$$

The first - best allocation is reached when $\tau = 0$, which is consistent with our previous finding. The PAYG surplus, denoted as B, then boils down to

$$B = \theta(z + 1)w - (\lambda_1 + \lambda_2)\, w(T - z)$$

Using equations (6), (7) and (8), B becomes

$$B = (\theta + \lambda_1)z\tau w$$

Of course, when individuals are given the actuarially fair scheme ($\tau = 0$), the PAYG surplus vanishes ($B = 0$). As τ increases, the PAYG surplus goes up for a given z. However, as individuals are discouraged from working longer [1], we go further away from the optimum z^*. The Laffer curve captures these contrasting effects on the PAYG surplus. There exists a rate τ^* that maximizes the PAYG surplus. This point is reached when the elasticity of retirement age z with respect to τ is 1. This paper aims at determining the τ^* that optimizes the funding of the PAYG system, in a model including more realistic dimensions.

[1] It can be easily shown that z decreases with τ with a standard utility function, such as log.

3 The benchmark model

The model analyzed in this section is a modified version of the stochastic neoclassical growth model with uninsured idiosyncratic risk and no aggregate uncertainty. Beyond the heterogeneity arising from uninsurable shock to household employment opportunities, life cycles features are also considered. Following here Castañeda, Diaz-Gimenez and Rios-Rull [1998], agents age stochastically. Upon death, households are replaced by other households of the same dynasty and are imperfectly altruistic towards them. Finally, like in Rust and Phelan [1997], retirement decisions are endogenous. From the age of 59 on, each year, the individual decides to retire the following year or remain in her current situation : employed, pre-retired or unemployed. This theoretical framework extends Rust and Phelan [1997]'s model to allow for wealth accumulation.

A last important feature of the model is the social structure adopted in this paper. For the calibration of the model, we rely on French statistics that categorize the population according to their skill level. Since we are interested in the reforms affecting workers of the private system (that covers 70% of the labor force), we retrain 3 broad categories: blue collar (unskilled workers and clerks) workers [2], white collar workers including (intermediate skilled) employees (or middle white collars) and (high skilled) executives. Wage profiles and levels, replacement rates, unemployment and pre-retirement transitions, mortality risk and age of end of education are specific to each social category. Finally, the model will be able to predict the retirement decision of each occupational group.

3.1 The life cycle model and employment opportunities

In this section, we define the exogenous stochastic variables of the model, namely the age of households, their employment opportunities and intergenerational social mobility. These stochastic processes are independent of each other.

3.1.1 Life Cycle

Each period, some households are born and some households die. For empirical reasons, we assume that there is no demographic growth. Households are born as workers. For sake of simplicity, individuals face a mortality from age of 59 on. In order to take into account a typical wage life-cycle profile, we assume that the population can be divided into three classes of age, the young, the adult and the mature individuals respectively denoted J, A and M. As a worker accumulates experience during its life-cycle, we assume that the efficiency of the labor input grows with the age of the agents. Thus, when a young worker becomes an experimented worker, his efficiency is multiplied by $1 + x_J$. When an experimented worker becomes an adult worker, his efficiency is multiplied by $1+x_A$, with $x_J < x_A$. The same process applies to mature people. The mature period encompasses the ages of 59 to 70, ($M = \{59, 60, ..., 70\}$). Since the legal retirement age is fixed to 60, from the age of 59 on, each agent chooses to remain in her current state (employed, pre-retired or unemployed) or retire the following period.

Each individual is born as a young worker. The probability of remaining a young (experienced) worker the next period is π_{JJ} (π_{AA}). Conversely, the probability of becoming an experienced (old) worker is $1 - \pi_{AA}$ ($1 - \pi_{JJ}$). From the age of 59 on, the individual of age

[2] Blue collars and clerks are merged into the same category as their characteristics in terms of unemployment risk and life expectancy are found to be rather similar in French statistics.

$z \geq 59$ faces a rising probability to die $(1 - \pi_{Mz})$. The mortality matrix takes into account the inequality between blue collars and white collars: under the benchmark calibration, unskilled workers' expected duration of retirement equals 18 years while executives enjoy 24 years of retirement on average. The matrix governing the age Markov-process is given by:

$$
\begin{array}{cc|cccccccc}
 & & & & & t+1 & & & & \\
 & & J & A & M59 & M60 & M61 & \cdots & M69 & R \\
\hline
 & J & \pi_{JJ} & 1-\pi_{JJ} & 0 & 0 & 0 & \cdots & 0 & 0 \\
 & A & 0 & \pi_{AA} & 1-\pi_{AA} & 0 & 0 & \cdots & 0 & 0 \\
 & M59 & 1-\pi_{M59} & 0 & 0 & \pi_{M59} & 0 & \cdots & 0 & 0 \\
t & M60 & 1-\pi_{M60} & 0 & 0 & 0 & \pi_{M60} & \cdots & 0 & 0 \\
 & M61 & 1-\pi_{M61} & 0 & 0 & 0 & 0 & \cdots & 0 & 0 \\
 & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
 & M69 & 1-\pi_{M69} & 0 & 0 & 0 & 0 & \cdots & 0 & \pi_{M69} \\
 & R & 1-\pi_{RR} & 0 & 0 & 0 & 0 & \cdots & 0 & \pi_{RR}
\end{array}
$$

3.1.2 Employment opportunities

There are three components in the real wage : a deterministic exogenous productivity trend growing at a rate of γ, the experience component whose profile has been described above, and an idiosyncratic risk. In Europe, and more particularly in France, only half of retirees were employed before deciding to retire, the other half being pre-retired or unemployed. Taking into account the idiosyncratic risk of being employed, unemployed or pre-retired is then essential in the understanding of retirement decisions, especially when a more actuarially fair pension system is present. In order to simplify our analysis, this idiosyncratic element of the real wage intervenes at the age of 59 only. When young or adult, people do not face the risk of being unemployed. At the age of 59, some agents become unemployed (U) and pre-retired (P). Transitions to these states are determined by exogenous probabilities denoted by π_u and π_p. Once pre-retired or unemployed, the individual remains pre-retired or unemployed, which is consistent with the French statistics. Exogenous transitions to pre-retirement or unemployment are specific to each social group : in particular, blue-collars and clerks face a higher risk of inactivity than white collars.

Finally, we assume that a newly-born household's social status is determined by her parents' rank. This social mobility is modelled by an exogenous Markov matrix

$$\pi(\epsilon'|\epsilon) = Pr\{\epsilon_{it+1} = \epsilon'_i | \epsilon_{it} = \epsilon_i\}$$

where ϵ_i (ϵ'_i) denotes the random variable embodying the social status of the father (of the son). It is assumed that, once born with a random social status (linked to that of her father), an individual's social status is not modified in her life-time.

3.2 The household's decision: retirement choice, consumption and wealth

3.2.1 Preferences

Households only derive utility from their consumption when their are alive as well as from the consumption of their progenies. The intertemporal utility function of an household is given by

$$\sum_{t=0}^{\infty} \beta^t \left\{ \sum_{s_t \in \mathcal{V}} \pi(s_t|s_{t-1}) u(C_t, l_t) + \left(1 - \sum_{s_t \in \mathcal{V}} \pi(s_t|s_{t-1})\right) \eta \sum_{s_t \in S1} \pi(s_{t+1}|s_t) \beta V(A_{t+1}, s_{t+1}) \right\} \quad (10)$$

where the period utility function u is strictly concave, the time-discount factor verifies $\beta \in]0, 1[$, consumption C_t and leisure l_t are positive. The variable $s_t \in S$ is a compact notation to denote the age, the employment opportunities and the social mobility of the household. This variable follows a finite state Markov chain with conditional transition probability given by

$$\pi(s'|s) = Pr\{s_{t+1} = s'|s_t = s\}$$

We denote $\mathcal{V} \in S$ the set of all the possible states s of being alive. Finally, the last term of the intertemporal utility function describes the utility derived by the parents from their bequests. The parameter $\eta > 0$ is related to the household concern for the welfare of his off-spring and then catches the degree of altruism in the economy. Thus, $V(A_{t+1}, s_{t+1})$ denotes the expected utility of a new-born child who begins his career according to a stochastic productivity ladder linked to that of her parents, conditionally to his age, and inherits a stock of wealth A_{t+1}. We assume that the instantaneous utility function u is a CRRA:

$$u(c) = \frac{(c^{1-\nu}(1-l)^{\nu})^{1-\tilde{\sigma}}}{1-\tilde{\sigma}}$$

with $\tilde{\sigma}$ the risk aversion and ν the elasticity of substitution between leisure $(1-l)$ and consumption. In addition, the household faces two sources of capital market inefficiency. The first stems from market incompleteness that prevents them from insuring against idiosyncratic risks. The second relies on a liquidity constraint : household are not allowed to run into debt ($A_{t+1} \geq 0$).

3.2.2 The stationary dynamic program

In order to define a stationary equilibrium, we divide all the variables by the gross rate of technological progress $(1+g)$. We denote stationary consumption and wealth by

$$c = C_t/(1+g)^t \quad \text{and} \quad a = A_t/(1+g)^t$$

whereas the real wage and the pension are denoted in stationary terms by

$$w = w_t/(1+g)^t, \quad \omega(s) = \omega_t(s)/(1+g)^t,$$

The household of age z has 2 state variables : the pair (a, s) which includes the realization of the household-specific process s and the beginning-of-period capital stock. The dynamic program solved by a household differs according to her age and employment status (retiree / non retiree). Retirement decisions are endogenous. Population dynamics and the distribution of employed, unemployed and pre-retired people are therefore affected by retirement behavior.

All agents determine their optimal saving and consumption profile taking into account financial market incompleteness and the borrowing constraint.

The occupational status (employed, pre-retired or unemployed) is a key element in the retirement decision since it determines current and future income flows as well as expected pensions. In order to keep our model within tractable bounds, the risk of becoming unemployed or pre-retired affects only the elderly who are concerned by the incentive scheme. Then, from the age of 59 on, individuals of age $z \geq 59$ choose whether to retire or not the following year by comparing the expected future value function at age $z+1$ when retired to the future value function at age $z+1$ if she remains in current state (employed, pre-retired or unemployed). When retired, individuals only choose their optimal consumption and the bequest. Since the households' decision problem is a finite-state, discounted dynamic program, an optimal stationary Markov solution to this problem exists. This solution gives the optimal consumption and retirement decision as a function of (a, s). Appendix A presents the optimizing programs.

3.3 The French pension system

The French pension system consists of a wide range of pension schemes. Farmers, civil-servant, wage earners and self-employed people subscribe to different retirement plans. In this paper, we focus on the pension plans of wage earners in private firms. Approximately 70 percent of the labor force falls under this so-called "General Regime".

The benefit that an individual is eligible to receive consists of two elements:

- The first one stems from a "basic general regime" whose benefits are based on age, years of contribution to the pension scheme and the employee's lifetime earnings. This regime is based on defined pension plans and managed by a State agency (CNAV). We shall hereafter refer to this regime as "General Regime" (GR).

- The second one is linked to mandatory complementary schemes, organized and managed on a socio - professional basis (MCSE for executive workers only and MCSNE for non executives). This pension is based on defined contribution plans. We shall hereafter refer to this regime as mandatory complementary schemes for executives (MCSE) and non executives (MCSNE).

Both retirement plans are pay-as-you-go systems. A detailed presentation of the French Social Security provisions can be found in Blanchet and Pelé [1997]. As shown in appendix B, in the model, rather than relying on calibrated replacement rates, the computation of pensions is based on real - life formulas.

Policy debates as well as this paper focus on how the computation of GR benefits could be modified in order to finance the Social Security deficit generated by the aging of the French population. Depending on the occupational group, 30 to 50% of the retirement pension is paid by complementary schemes. Obviously, MCSNE and MCSE cannot be discarded when analyzing retirement choices. Besides, the General Regime is directly managed by the government while complementary schemes are managed by trade-unions and representatives of employers. As a result, GR and MCSNE along with MCSE are characterized by distinct budgets. In this paper, we will indeed present *separate* expected deficits as well as the *total* deficit, in order to measure the impact of Social Security reforms on the total financial stress.

3.4 Definition of the equilibrium

Given the vector of prices (r, w), the stationary equilibrium consists of households' choices for consumption, savings and retirement $\{c(a,s), a'(a,s), \Psi(a,s)\}$, value functions $v(a,s)$ and $V(a,s)$, a stationary distribution of households $\lambda(a,s)$ and a set of aggregate variables (A, R^{SS}, D^{SS}, R^{MCSNE}, D^{MCSNE}, R^{MCSE}, D^{MCSE}) where D^X (respectively R^X) refers to expenditures (respectively the revenues) of the retirement scheme X. The stationary equilibrium is such that:

(i) The real interest rate is given, which is consistent with a small open economy hypothesis. This leads to a constant capital to labor ratio, thus making real wages w exogenous.

(ii) Saving decisions $a' = g(a,s)$ and retirement behavior $\psi = \Psi(a,s)$ are solutions to the lifetime maximization program where

$$\Psi(a,s) = \begin{cases} 1 & \text{if} \quad v(a,\{s,z\}) \geq v(a,\{R,z\}) \\ 0 & \text{otherwise} \end{cases}$$

for $s = e, u, p$. Finally, let $a' \equiv A(a,s)$ be the households' policy that depends on her state on the labor market (employed, pre-retired or unemployed). $A(a,s)$ is such that:

$$\mathcal{A}(a,s) = \Psi(a,s)g(a,\widehat{s}) + [1 - \Psi(a,s)]g(a,R)$$

where an agent's policy in state $\widehat{s} = e, u, p$ is denoted by $a' \equiv g(a,\widehat{s})$.

(iii) The new-born's utility $V(a,s)$ is similar to the utility of people who begin working $v(a,s)$.

(iv) The endogenous probability distribution$\lambda(a,s)$ is the stationary distribution associated with $(A(a,s), \pi(s'|s))$ such that:

$$\lambda(a',s') = \sum_{s} \sum_{\{a:a'=\mathcal{A}(a,s)\}} \lambda(a,s)\pi(s'|s)'$$

(v) Budget constraints of the general regime (GR) and the complementary schemes (MCSNE and MCSE) are satisfied:

$$R^{SS} + R^{SS}_{tr} = D^{SS} \tag{11}$$
$$R^{MCSNE} + R^{MCSNE}_{tr} = D^{MCSNE} \tag{12}$$
$$R^{MCSE} + R^{MCSE}_{tr} = D^{MCSE} \tag{13}$$

Tax rates endogenously adjust to balance equations (11) to (13). Each budget equation takes into account the transfers paid by unemployment services (R_{tr}) to the GR, MCSE and MCSNE on behalf of unemployed and pre-retired individuals. As a result, periods of inactivity are included in the contributing years to the PAYG system.

(vi) Aggregate capital stock is given by

$$A = \sum_s \sum_a \lambda(a,s) g(a,s)$$

Given the specification of preferences and the various constraints, it is impossible to find an analytical solution to this equilibrium. We implement numerical techniques based on a discretization of state variables (see Sargent and Ljungqvist [2000] for a detailed presentation of the methodology).

4 Calibration and quantitative evaluation

4.1 Calibration on French data

This section presents the calibration of the demographic structure, the idiosyncratic labor income risk, the life-cycle profile of labor earnings, the Social Security arrangement and the preferences and technology parameters. Our strategy is to calibrate in order to match selected observations of the French postwar economy. More precisely, we choose to calibrate the model before the French Prime Minister Balladur 1993 reform which plans to progressively modify some key features of the Social Security system. Indeed, the implementation of the reform is gradual so that the full impact of the reform will not be observed before 2008.

4.1.1 Technological trend, real interest rate and preferences

Following Charpin [1999]'s report, the technological trend is set to 2% a year. The annual real interest rate equals 5% which corresponds to the average value observed in the last 20 years in France (Artus [1996]). The transformed utility function is :

$$\frac{c^{1-\sigma}}{1-\sigma}\vartheta(l) = \frac{(c^{1-\nu}(1-l)^{\nu})^{1-\tilde{\sigma}}}{1-\tilde{\sigma}}$$

So, by comparing to two terms of this equation, we have $(1-\nu)(1-\tilde{\sigma}) = 1-\sigma$. The literature provides values for the risk aversion coefficient σ. Microdata suggest that $\sigma = 2$ (Attanasio, Banks, Meghir and Weber [1999]). Empirical papers implemented on European and US data find that σ lies between 1 and 3. We set $\sigma = 2$, which also could be interpreted as an average value of these different studies.

Following Castañeda *and al.* [1998], we impose $1 - l = 2/3$. Unemployed and pre-retired people as well as retirees enjoy full time leisure ($l = 0$). The elasticity of substitution between consumption and leisure, by affecting the willingness to work, is one of the key parameters in the model. However, the observed distribution of retirement ages hardly reveal agents' preferences. Indeed, the current pension system offers little flexibility concerning the choice of retirement age. As underlined by Blanchet and Pelé [1997], "*there are strong incentives not to retire at a reduced rate, even if delaying after 60 implies giving up pensions. Finally, after reaching the full rate, we observe (as in previous cases) a heavy tax on work*". This conclusion only allows to identify an interval of admissible values for the parameter defining the preference for leisure. Under a minimum value of preference for leisure, individuals delay retirement beyond their full rate age, while a high value would allow to observe exits before the full rate. We determine

these two interval bounds by simulations and set the benchmark value of preference for leisure to the average of the upper and lower bounds.

The discount factor is set to 0.96. In the benchmark calibration, the altruism is set to $\eta = 0.9$, which corresponds to the value chosen to replicate the ratio of bequest to financial asset of 1.4%, as observed in the French data (Arrondel and Laferrère [1996]).

Finally, preferences measure the welfare of one individual. In order to take into account the lifetime family structure, all revenues (wages and pensions) are deflated by "consumption units" (CU). We use information about CUs by age and by social status (INSEE [1999b]) to get table 1.

Table 1: Consumption Units by Social Status and by age

	J	A	M	R
Executives	1,4000	1,8500	1,5000	1,3000
Middle white collars	1,4000	1,8500	1,5000	1,3000
Clerks and Blue-Collars	1,5293	2,0209	1,6385	1,4201

Life expectancy at 60 years old equals 24.4, 20.7 and 18.6 years for executives, middle white collars and blue collars respectively (Charpin [1999]). Blanchet and Monfort [1996] report life expectancy at 65 years old. We infer from this information the decrease in surviving probabilities between these ages, assuming that this decline applies in a similar way to all social groups. Consistent with INSEE [1996], death probabilities reported in table 2 display an exponential pattern with age.

Table 2: Death probabilities

	Executives	Middle Wh. Collars	Blue collars
$1 - \pi_{M59}$	0,0333	0,0390	0,0433
$1 - \pi_{M60}$	0,0342	0,0403	0,0448
$1 - \pi_{M61}$	0,0351	0,0416	0,0464
$1 - \pi_{M62}$	0,0361	0,0430	0,0482
$1 - \pi_{M63}$	0,0371	0,0444	0,0501
$1 - \pi_{M64}$	0,0382	0,0460	0,0521
$1 - \pi_{M65}$	0,0394	0,0478	0,0543
$1 - \pi_{M66}$	0,0407	0,0496	0,0567
$1 - \pi_{M67}$	0,0420	0,0516	0,0593
$1 - \pi_{M68}$	0,0434	0,0538	0,0622
$1 - \pi_{M69}$	0,0449	0,0561	0,0654
$1 - \pi_{RR}$	0,0466	0,0587	0,0689

4.1.2 Wages, employment risks

Experienced people's wages are higher than younger employees'. The lifetime evolution of wage is the result of this fact (table 3). The data given by INSEE [1999a] are aggregated in order to fit our age structure. Data are extracted from the 1994 database as this is the year for which statistics are close to year 1993, when the Balladur reform was voted.

Table 3: Lifetime wages in France (in KF)

age	-30	30-54	+55
Executive	214.79	325.79	391.71
Midd. Wh. Coll	140.93	186.78	225.59
Blue Collars	100.06	124.25	126.04

This lead to wage growth factor of 1,24 for clerks and blue collars, 1,33 for middle white collars and 1,52 for executives in the first two periods of life. Between the first and third period of life, wage growth equals 1,26 for clerks and blue collars, 1,6 for middle white collars and 1,83 for executives. In contrast to other categories, clerks and blue collars face a downward wage profile when old.

At the age of 59, agents can loose their job by being either pre-retired or unemployed. The calibration of these events require to know their probability (π_p and π_u) and their consequences on income. Let θ_u and θ_p the replacement ratios associated with unemployment benefits and pre-retirement income respectively. Table 4 sums up the data taken from Colin, Iéhlé and Mahieu [2000].

Table 4: Employment risks for the elderly

age	θ_u	θ_p	π_u	π_p
Executives	0,6	0,6	0,28	0,1
Middle White Collars	0,59	0,63	0,26	0,24
Clerks and Blue Collars	0,62	0,68	0,2	0,3

In addition, the correlation between the parents' human capital and that of their off-spring is given by the social mobility matrix extracted from INSEE [1995] (table 5).

This matrix implies that 18,31% of the population consists of executives, 25,79% belongs to the middle white collars while 55,9% of the population are clerks and blue collars.

As shown by Colin *and al.* [2000], the age of end of education differs across categories (table 6). This heterogeneity in the age of end of education has a tremendous impact on retirement

Table 5: Intergenerational Social Mobility Matrix

		Son's Status $(t+1)$		
		Executive	Midd. Wh. Coll.	Blue Collars
Fathers' Status (t)	Executive	0.40774	0.3187	0.27356
	Midd. Wh. Coll.	0.21912	0.35068	0.4302
	Blue Collars	0.092851	0.19521	0.7119

Table 6: Age of end of school education

	Executives	Midd. Wh. Coll.	Blue Collars
k^{eva}	22,2	19,5	17,4

choices which are conditional to a minimum duration of contribution.

4.1.3 Social Security

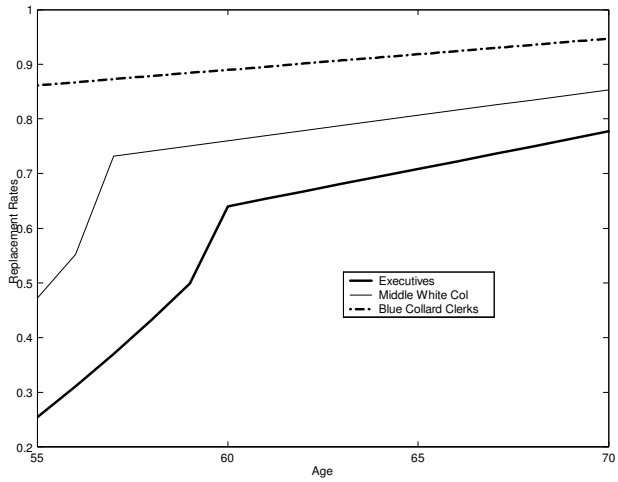
Appendix B.3 summarizes the calibration on the French pension system. Rather than relying on calibrated replacement rates, the computation of pensions is based on real - life formulas. Figure 1 illustrates the replacement rates predicted by the model under the current retirement rules : individuals who contributed 37.5 years are allowed to a maximum of 50% of their annual average wage truncated to the Social Security cap and paid by the GR, plus an additional pension from mandatory complementary schemes. The model provides good proxies for replacement ratios (table 7).

Executives, middle white collars and blue collars contribute during the required number of

Table 7: Replacement Ratios

	Net Wage	
in %	Model (individuals of 60 years old)	Data
Executives	64	54
Midd. Wh. Coll.	76	80
Blue Collars	88	92

Figure 1: Replacement rates in the current French pension (150 contributive quarters)



contributive quarters _ 150 under the current system _ at age 60, 57 and 55 respectively. If they retire before contributing 150 quarters, they bear a strong decrease in their pension (figure 1). In addition, should they want to delay retirement, they get little increase in their pension: only the pension paid by contribution plans, MCSNE and MCSE, adds to the pension in case of continued work. Figure 1 provides a first insight into the constraints inherent to the French retirement provision : retirement provisions entice individuals to retire as soon as they reach the full rate[3], at age 60, 57 and 55 for executives, middle white collars respectively. However, the early retirement age is fixed to 60 years old in France.

4.2 Retirement decisions in the nineties : is the model consistent with the data?

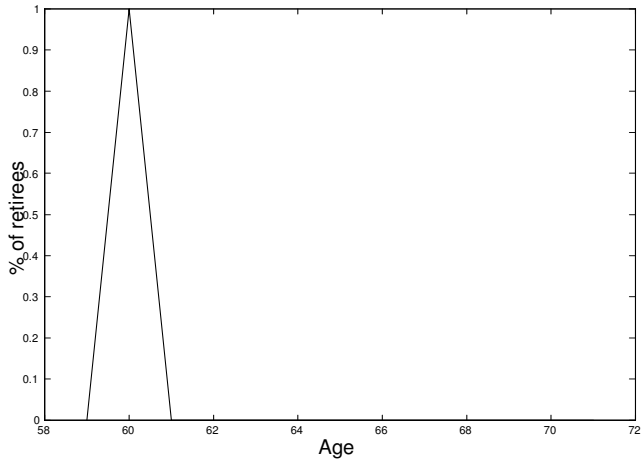
In order to check the empirical relevance of our model, we present in this section the distribution of retirement age, the dependency ratio and the contribution rates obtained with the benchmark calibration.

Figure 2 presents the distribution of retirement age in the benchmark situation. In view of the age of end of education, all categories, whether employed, pre-retired or unemployed, retire at the age of 60, which is the early retirement age in France. Figure 2 shows that the early age of retirement forces blue collars and intermediate professions, who entered the job market at very young ages, to remain at work longer than required by the pay-as-you-go system.

The French hazard rates out of labor force estimated by Blanchet and Pelé [1997] displays much more heterogeneity than figure 2, which illustrates that our model does not take into account incomplete careers, specific female participation behavior or health status. Indeed, taking into account additional sources of heterogeneity would have made the model less tractable. In spite of the difference between Blanchet and Pelé [1997] and figure 2, we argue that our model remains relevant for the purpose of this paper. First, early exits are taken into account in the model since pre-retirement occur at the end of working life. However, only transition to

[3]The age of the full rate is the age when individuals reach 37.5 contributive years.

Figure 2: Distribution of retirement age before the Balladur reform (37.5 contributive years)



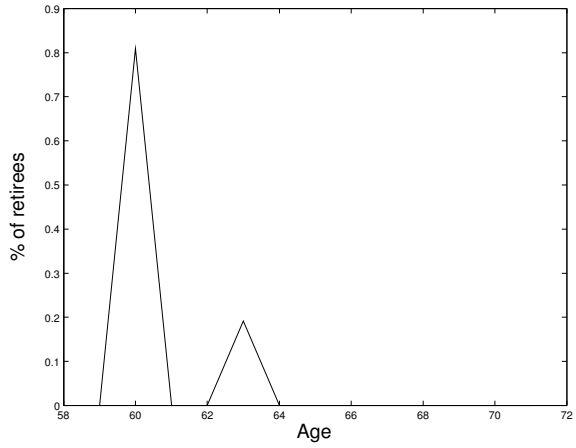
retirement is displayed in figure 2. Secondly, we want to show that, in spite of the streamlined heterogeneity, the model is able to generate very heterogeneous retirement ages when incentive schemes are introduced in combination with wealth. Finally, the distribution of hazard rates in Blanchet and Pelé [1997] actually results from a very homogeneous behavior : nearly all individuals retire at the age of their full rate, which is consistent with the agents' behavior in the model.

The dependency ratio equals 43.83% in the model, which is close to 39% observed in France today (Charpin [1999]). The model determines the payroll taxes that balance the Social Security budgets. The workers' equilibrium contribution rate to the General Regime equals 8.35% versus 7.85% in the data. For complementary schemes (MCSNE and MCSE), the equilibrium rates paid by workers are respectively 3.25% and 8.63% in the model versus 2.92% and 6.96% in the data (Charpin [1999]). The model develops a stationary equilibrium. As a consequence, we are unable to analyze the effects of baby boomers which refers to a transition issue. This explains why we slightly over-estimate the ratio of retirees to contributors as well as the contribution rates. Hence our calibrated model seems to be able to replicate the main observed features of the French PAYG pension system.

5 Retirement behavior and expected Social Security Deficit

In this section, we assess the impact of the demographic changes on the total Social Security deficit. The Social Security system is then modified to induce the elderly to work longer. The effectiveness of such a reform is assessed. Political debates on Social Security reforms in France focused only on the defined benefit General Regime (GR), as the mandatory complementary schemes (MCSNE and MCSE) are managed by representatives of workers and employers. As a result, we measure in this section what would happen if the pensions paid by the General Regime include incentives to work beyond the full rate. The rules regarding retirement pensions paid by MCSNE and MCSE are left unchanged. Pre-retired and unemployed individuals are not given the incentive plans. In addition, we do not modify the strong penalties associated

Figure 3: Distribution of retirement age after the Balladur Reform (40 contributive years)



with early retirement, as we are interested in delaying the retirement age to partially reduce the expected Social Security deficit, and not to restore the global optimality of the system.

5.1 Taking into account the Balladur 1993 Reform

Even if the 1993 Reform is not fully implemented yet, we choose to take into account this permanent change in Social Security provisions.

The Balladur 1993 reform mainly lengthens the duration of contribution from 150 quarters to 160 quarters. The model predicts that only executives will delay their retirement since they reach 160 quarters of contribution at the age of 63 (figure 3). Middle and unskilled workers who now reach the full rate at the age of 58 and 60 will not modify their retirement decisions. As in section 4.2, all agents retire as soon as the full rate is reached. Finally, since only 18% of the population are executives, the lengthening of working period of high skilled workers slightly improves the dependency ratio : the latter declines to 41.81%, which leads to a decrease in the workers' equilibrium contribution rate to the General Regime (7.8%) and to complementary schemes (3.2% for MCSNE and 8.45% for MCSE). Finally, figure 3 suggests that only a reform that puts off the retirement age of unskilled workers (who constitutes 50% of the labor force) may significantly improve the dependency ratio.

To grasp the intuition behind the distribution of retirement age, figure 4 plots the replacement rates computed after the Balladur Reform : with the lengthening of contributive quarters, replacement rates shift to the right. The structure of GR provisions is not modified:

- before the age of the full rate, individuals bear a strong decrease in pensions.
- after the age of the full rate, the increase in the pension is weak in case of continued work

Furthermore, we compute the marginal tax on continued work denoted $\tau_{marginal}$. If an individual decides to postpone his retirement by one year, his pension level will not adjust so

Figure 4: Replacement rates after the Balladur Reform (160 contributive quarters)

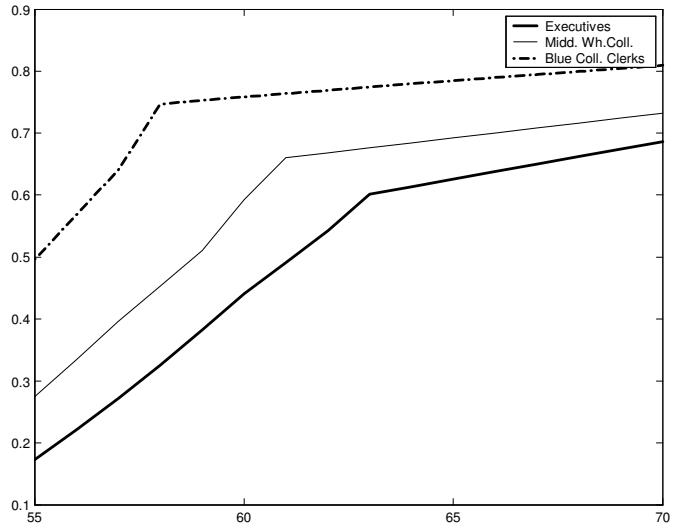


Table 8: Marginal Tax on Continued Work after the Balladur reform (in %)

General Regime - GR										
Age	60	61	62	63	64	65	66	67	68	69
Executives	11.01	14.4	40.86	47.23	47.44	47.57	47.69	47.82	47.96	48.09
Midd. Wh. Coll.	69.82	70.04	70.27	70.50	70.74	70.98	71.23	71.48	71.74	72.00
Blue Coll.	93.91	94.32	94.73	95.15	95.98	96.35	96.74	97.13	97.53	97.94
Mandatory Complementary Schemes - MCSNE+MCSE										
Age	60	61	62	63	64	65	66	67	68	69
Executives	13.40	15.78	18.35	39.2	41.1	43.1	45.1	47.1	49.1	51.2
Midd. Wh. Coll.	21.9	23.1	24.4	25.6	26.9	28.2	29.5	30.9	32.2	33.6
Blue Coll.	24.0	24.9	25.8	26.8	27.7	28.7	29.7	30.6	31.7	32.7

as to compensate for the additional payroll tax he pays (explicit tax) and for the fact that he receives pension benefits for one fewer year (implicit tax). Let us define

$$\tau_{marginal}(z) = \frac{\left(\sum_{i=0}^{T(z)} \frac{P_z}{(1+r)^i} - \Pi_{zz+1} \sum_{i=1}^{T(z+1)} \frac{P_{z+1}}{(1+r)^i}\right) + \theta w(z)}{w(z)}$$

where $\tau_{marginal}(z)$ is the marginal tax on continued work for an individual of age z, P_{z+1} the pension when retirement occurs at age $z+1$, Π_{zz+1} the survival probability between age z and $z+1$, $T(z)$ life expectancy at age z, θ the payroll tax and $w(z)$ earnings at age z, r the rate of return on financial markets. Table 8 reports the values obtained for the current Social Security provisions. The taxes are computed for years beyond the minimal retirement age (60 years old).

In the General Regime, beyond the age of the full rate, the tax on continued work is large, in particular for blue collars and middle white collars who experience a lower life expectancy than executives. In addition, the tax on continued work is lower for complementary schemes since

they are based on defined contribution plans. Before the full rate, as the retirement pension increases with age, the tax is lower than the contributive rate.

In this paper, we modify the incentives controlled by the government, namely retirement provisions paid by the General Regime. The implicit tax of complementary schemes is left unchanged. This implies that, when individuals delay retirement, MCSNE and MCSE experience an improvement in their budget deficit.

5.2 Expected Social Security deficit

From now on, taking into account the 1993 Reform, we keep all the parameters of the model constant. Only the transition matrix describing the population dynamics and the Social Security program are modified.

Following the predicted evolution of the French population (COR [2001]), we assume that there will be an increase in life expectancy: in year 2040, the life expectancy at age 60 is expected to go up by 6 years (COR [2001]). For want of further information about the expected mortality risk across social groups in 2040, we finally assume that the increase in life expectancy applies homogeneously to all occupational categories. The increase in the number of retirees is then explained by the increase in life expectancy, thereby discarding the effect of baby boomers on the dependence ratio.

The dependence ratio as predicted by the model equals 56.6%. The French estimates hover around 60%. The model predicts that the modification in the demographic environment does not affect the distribution of retirement age that mimics figure 3. Even if they expect a longer life, individuals still decide to retire as soon as they reach the full rate. However, asset holding increases significantly : individuals save more in order to insurance themselves from the risk of outliving their assets. Without any Social Security reform, the increase in life expectancy is not significant enough to make them willing to work longer.

Furthermore, holding all payroll rates constant, demographic changes, by deteriorating the dependency ratio, generate deficits of the General regime (GR) and the complementary plans (MCSNE and MCSE). Approximately 29% of the total pensions are not financed in 2040, which is consistent with French official estimates (COR [2001]). Social security reforms may reduce this alarming percentage. The following sections measure the ability of incentive schemes to finance the expected deficit.

5.3 Actuarially Fair Scheme and Retirement Behavior

We first analyze the incidence of actuarially fair incentives on retirement behavior and on the total expected Social Security deficit as well as the strong interaction between this policy and the wealth accumulation process.

5.3.1 Definition of the actuarially fair scheme

Let $\lambda_2^*(z)$ be the actuarially fair bonus given to an individual of age z who is willing to work beyond the required 40 years of contribution. As long as the individual has not contributed long enough to reach the full rate, $\lambda_2^*(z) = 0$.

Let us consider an individual of age z who faces two choices: either he claims Social Security benefits now and receives his pension until his expected date of death or he continues working

Table 9: Actuarially Fair Scheme

$\tilde{r} = 0\%$	$\lambda_2^*(z+1) - \lambda_2^*(z)$								
Age $z+1$	61	62	63	64	65	66	67	68	69
Executives	0	0	3,35	3,61	3,92	4,26	4,63	5,04	5,51
Middle White Collars	3,58	3,9	4,26	4,66	5,12	5,62	6,2	6,86	7,61
Blue Collars, Clerks	3,75	4,12	4,52	5,04	5,58	6,2	6,9	7,72	8,66

and retires at age $z+1$, knowing that life expectancy is lower at age $z+1$. The actuarially fair bonus $\lambda_2^*(z)$ is such that both options are neutral for the Social Security budget:

$$\Pi_{zz+1} \sum_{i=1}^{T(z+1)} \frac{(\lambda_2^*(z+1)+0.5)w^{ref}(z+1)}{(1+\tilde{r})^i} - \theta w(z) = \sum_{i=0}^{T(z)} \frac{(\lambda_2^*(z)+0.5)w^{ref}(z)}{(1+\tilde{r})^i} \tag{14}$$

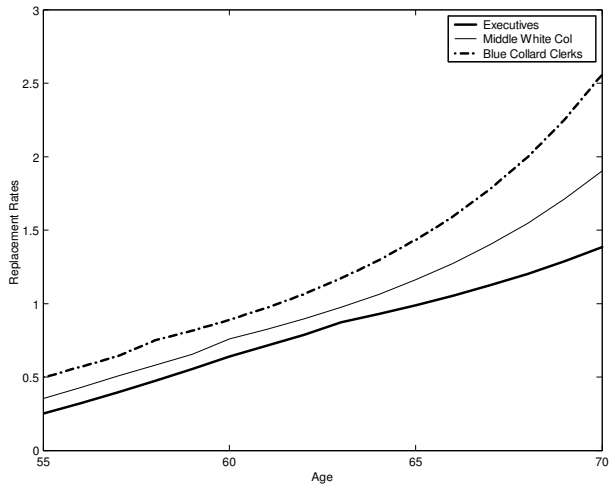
where $w^{ref}(z+1)$ denotes the life-time average wage and $\tilde{r}$ the actualization rate. $\lambda_2^*(z)$ is such that the postponement of retirement from age z to age $z+1$ is neutral for the Social Security budget. Equation (14) states that the pensions paid by the Social Security if the individual retires at age $z+1$ minus the contributions collected on wages earned during year z equals the pensions paid in case of retirement at age z.

Equation (14) implies that, as the individual grows older, he has to be given an increasing bonus to make him work longer. Indeed, the actuarially fair bonus has to compensate the worker for the increasing probability of death. In table 9, for a given occupational group, executives for instance, the increase in the marginal bonus $(\lambda_2^*(z+1) - \lambda_2^*(z))$, as the individual grows older, mirrors the decrease in life expectancy. Moreover, actuarially fair bonus mimics the inequality of life expectancies across occupational groups : at all ages, blue collars and clerks who experience a lower life expectancy than executives receive a higher bonus than high skilled workers.

Furthermore, the computation of the actuarially fair bonus is based on an actualization interest rate $\tilde{r}$. In the benchmark scenario, only one interest rate is considered : from a public finance stance, the return on the PAYG system is the relevant one. As the productivity efficiency gains are already incorporated into the reference wage w^{ref}, it remains the population growth rate. Since in our setting the population remains constant, we impose $\tilde{r} = 0\%$. The General Regime immediately shares the additional surpluses among the current generation of retirees. In a steady state equilibrium, the probabilities in equation (14), when taken over the whole population, give the proportion of retirees still alive who are likely to benefit from the incentive scheme.

Figure 5 illustrates how the introduction of the actuarially fair scheme affect replacement rates. After the Balladur reform, individuals are required to contribute 160 quarters to the GR before being entitled to a maximum of 50% of their average wage. Executives, middle white collars and blue collars meet this condition at age 63, 60 and 58 respectively. Since the actuarially fair scheme only applies to continued work, the strong penalties in case of early retirement are not modified. In contrast to figures 1 and 4, in case of delayed retirement, workers get a significant increase in replacement rates as they age, since the additional pension compensates them for the decrease in their life expectancy. Section 5.3.2 measures the impact of these modified retirement provisions on retirement behavior.

Figure 5: Replacement rates with actuarially fair scheme (160 contributive quarters)



5.3.2 Impact of the actuarially fair scheme on retirement behavior

What happens when individuals are given the actuarially fair rate? All categories of employed workers postpone their retirement (figure 6). An actuarially fair rate does entice workers to delay their retirement. In contrast, pre-retired and unemployed, who do not benefit from the incentive schemes, do not postpone retirement. The dependency ratio declines from 60% to 50% (see Table 10). By definition, if individuals are given the actuarially fair bonus, it does not help finance the expected General Regime deficit (Column (1) of table 10). In contrast, complementary schemes based on defined contribution plans (MCSNE and MCSE) benefit from the fact that workers do defer their retirement. The total reduction in expected deficit then equals 10.4%. However, as the public regime is the main part of the expected deficit, actuarially fair incentives may not be the best way to reduce the total deficit. Moreover, there is no compensation between the different regimes: the incentives in the public regime must be determined in order to minimize its expected deficit.

Executives and middle white collars cease to work on average at the age of 67-68 and blue collars at 63 (Figure 6). However, in all categories, some retirements occur before these peaks. It then appears some heterogeneity in retirement choices both across and within social categories, but also across the labor market status.

5.3.3 Multidimensional Heterogeneities

The heterogeneity across individuals of different labor status is the easiest to explain. As pre-retired and unemployed people do not receive any incentives, they keep on claiming Social Security provisions at their full rate age.

The heterogeneity across social categories is more subtle and illustrates the two opposite effect of wealth on retirement age. The first effect is illustrated in figure 7 that reports value functions of an executive of 63 years old who considers retirement the following year. In order to make up his mind, he compares the value function of a person who retires at age 64 to

Figure 6: Distribution of retirement age when individuals are given the actuarially fair scheme ($\tilde{r} = 0\%$)

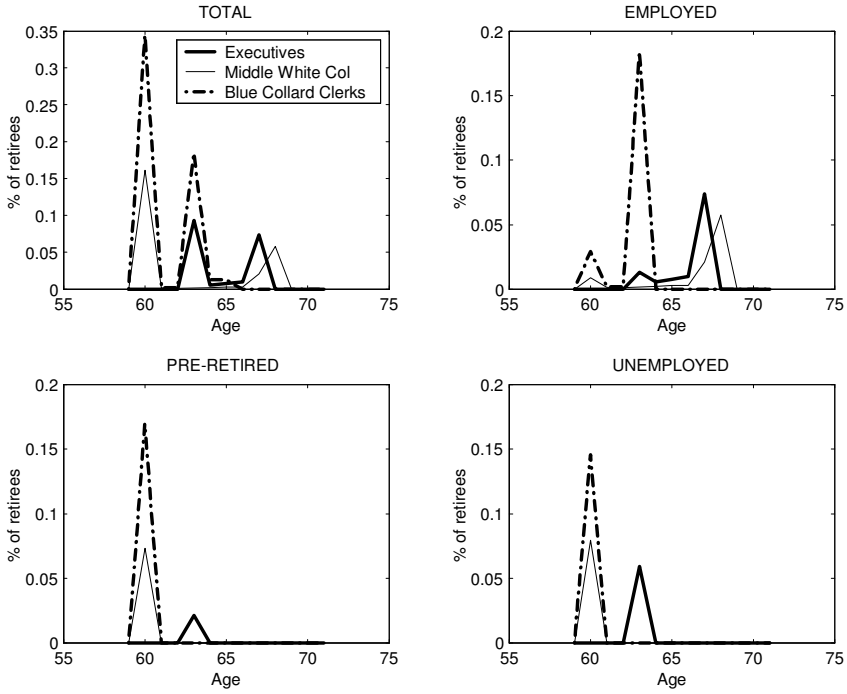
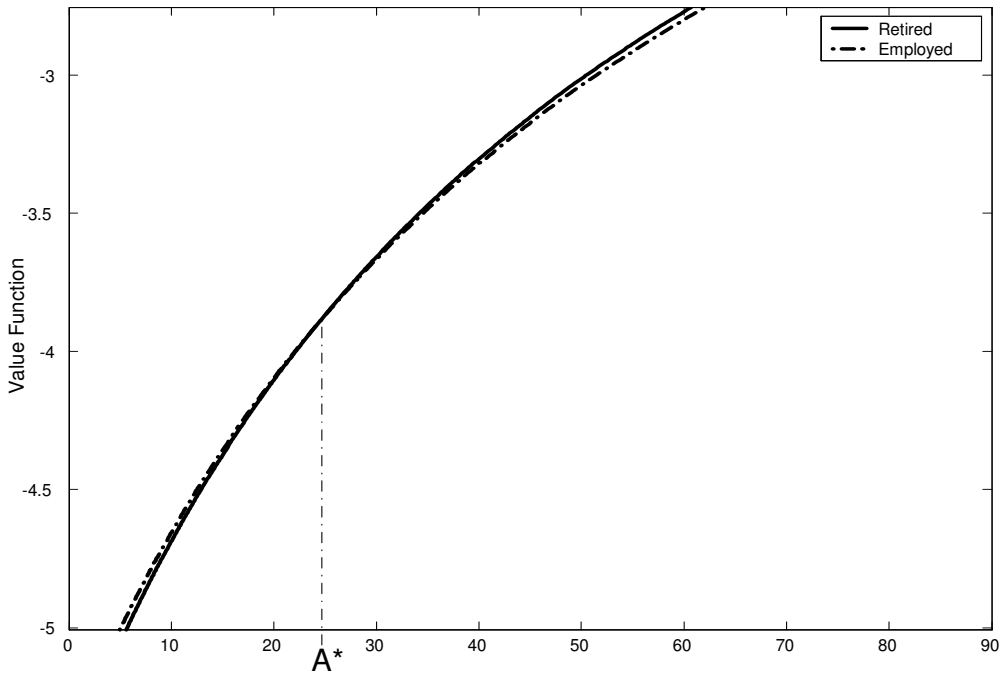


Table 10: Actuarially fair incentives and SS deficit ($\tilde{r} = 0\%$)

Expected decline in Social Security Deficit (%)				
GR (1)	MCSNE (2)	MCSE (3)	Total (4)	Dependency ratio
0,0	-30,0	-23,1	-10,4	50,0

Recall that GR is the General Regime based on defined pension plans. MCSNE and MCSE are mandatory complementary schemes based on defined contribution plans. Figures in columns (1) to (4) are changes in each deficit. The benchmark SS deficit is the one computed for year 2040 without SS reforms

Figure 7: Value Function of Executives of 64 years old



that of a worker of 64 years old. The value functions intersect when his financial holding equals $A^* = 24.16$. If his current wealth is larger than A^*, the executive would rather retire the following year. If the executive is not rich enough ($A < A^*$) today, he chooses to keep on working next year. The model actually yields an array of wealth thresholds above which individuals of each social category decide to retire. Table 11 reports these thresholds for each retirement age (first column) and each social group. For instance, blue collars of 59 years old who consider retiring next year must have a current wealth larger than 9.42 in order to cease working at age 60.

A^* is systematically the highest for executives and the weakest for blue collars. What does it mean? Executives are the most willing to work longer. Their wage is high relatively to their pension (their replacement ratio is the lowest) and to the expected wage of their children, given the social mobility. This is not the case for blue collars, and, to a lesser extent, for middle white collars. It must be noticed that the reference to the expected wage of their children hugely depends on the altruism and the social mobility considered in the model. The combination of wages earned when employed associated with higher pensions when retired allows the individual to accumulate assets. This desire to save stems from her concern for the welfare of her off-spring. Inherited capital constitutes an insurance against bad luck in the drawing of social status at the beginning of life. This fear for children's future is particularly keen for executives whose off-springs bear the risk of a deterioration of their social status. The desire to accumulate asset make executives postpone retirement.

However, to fully understand the retirement age across social categories, it is necessary to consider the wealth distribution. The second effect of wealth tends to bring forward retirement.

Table 11: Wealth Threshold in Retirement Decision Rules A^*

Age	Executives	Middle Wh. Coll.	Blue Coll. and Clerks
60	165,99	27,00	9,42
61	165,99	24,04	7,87
62	165,99	21,73	6,53
63	29,03	18,87	0
64	24,16	15,91	0
65	18,87	12,31	0
66	13,87	9,04	0
67	5,79	1,24	0
68	2,87	0	0
69	0	0	0
70	0	0	0

As can be seen on figure 6, despite an inferior threshold, some middle white collars delay more their retirement than some executives because they are less wealthy. As the threshold of blue collars is weak, their financial asset level, even this latter is inferior to the other social categories one, allows them to retire before 63. The impact of wealth on retirement decision tends to bring forward the retirement date.

Heterogeneity within each social group mirrors wealth heterogeneity. The wealthiest are not responsive to incentives. This effect appears for instance on figure 6: blue collars' retirement age spans from 60 to 63. The unskilled workers who retire before 63 inherited a substantial wealth from their parents who belonged to higher social categories. They benefited from the precautionary savings of their parents: inherited savings then do insure the off-spring against the risk of being born in a lower social group. They are thus rich enough to discard the incentive scheme. This feature is exacerbated in the case of middle white collars whose retirement age spans from 60 to 68. Similarly, some executives belonging to a dynasty of executives are wealthy enough to completely disregard incentives and to retire at the age of their full rate (63 years old). The social mobility explains the wealth heterogeneity across agents belonging to the same social class.

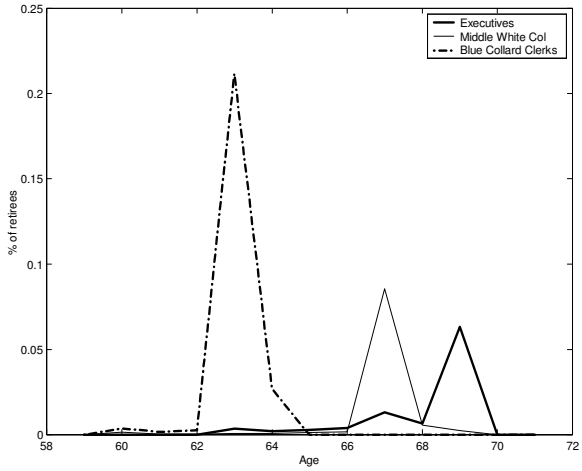
5.3.4 Impact of altruism and social mobility

The social mobility via the bequest motive seems to play a crucial role in the different kinds of heterogeneity in retirement age generated by incentive schemes. What happens when we suppress the social mobility across generations (son of executives are executives, etc.) ?

Figure 8 displays the distribution of retirement decisions for workers only [4] when the social mobility across generations is captured by the identity matrix. A complete reproduction scenario leads inherently to much more wealth homogeneity within each social group but also decreases the aggregate wealth since the precautionary savings against social mobility risk is now absent of the model. This is particularly true for executives as they expect higher wages for their descendants. This is why there is now less age retirement heterogeneity inside each social group, whereas executives delay more their retirement. In a stationary environment, the large decrease

[4] Indeed, as pre-retired and unemployed do not receive any incentive, they do not modify their retirement behavior.

Figure 8: Retirement decisions of employed individuals without social mobility across generations



in their financial asset provokes a traditional negative wealth effect on leisure. This effect is dominant and brings forward the retirement age of the executives social group.

The role of this wealth effect can be de-emphasized by examining a variation in the degree of altruism (η). Figure 9 displays the asset holding to income ratio (A/Y). Recall that the benchmark value is $\eta = 0.9$. As altruism decreases, individuals reduce their savings for bequests motive, which results in a steady fall in the asset holding to income ratio. Figures 10 and 11 display, for increasing values of altruism η, the distribution of retirement age.

First, as individuals decrease their savings for bequest motives, we observe less heterogeneity within each social group. Furthermore, it is noticeable that when individuals care less about their children, they are likely to work longer. With $\eta = 0.9$, the wealthiest unskilled workers retire at age 60 while those with lower wealth postpone retirement with a peak at age 63. As altruism decreases, all blue collars retire at age 64. With $\eta = 0.2$, all blue collars accept to retire at age 65. Similarly, as altruism declines, all executives and middle white collars accept to delay retirement until the age of 69. None of them is rich enough to retire earlier.

This last point also indicates that the benchmark calibration constitutes the worst case scenario for our incentive schemes. As individuals delay retirement when altruism is low, we observe a decrease in the dependency ratio for low values of η (Figure 9).

6 The Laffer curve

This section aims at assessing the incentive schemes which could minimize the public Social Security expected deficit.

6.1 Pure PAYG pension system and optimized incentives

Individuals now receive a fraction $(1 - \tau)$ of the actuarially fair scheme. Table 12 displays the impact of these different schemes on the expected public Social Security deficit.

Figure 9: Change in Total Social Security Deficit and Asset Holding as a function of altruism (η)

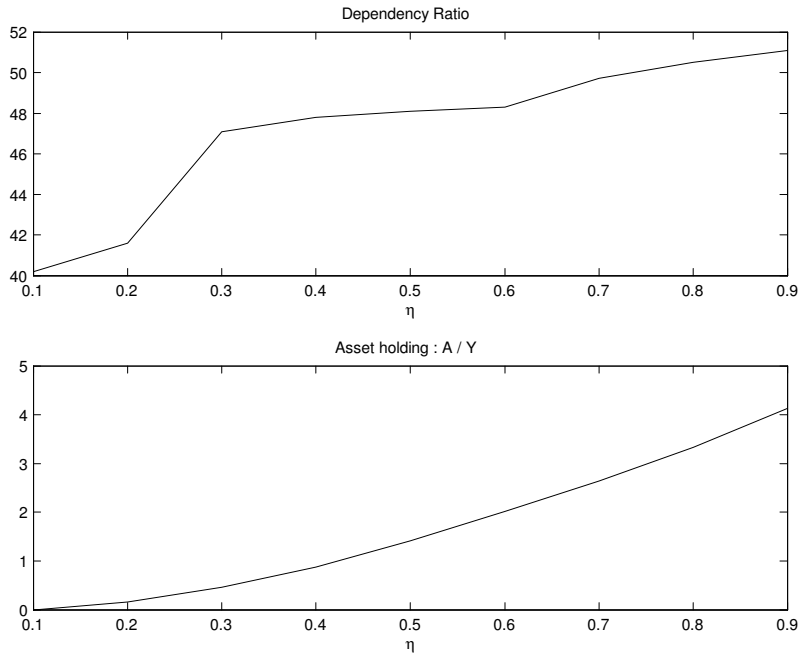


Figure 10: Distribution of retirement age of employed individuals as a function of altruism (η) (I)

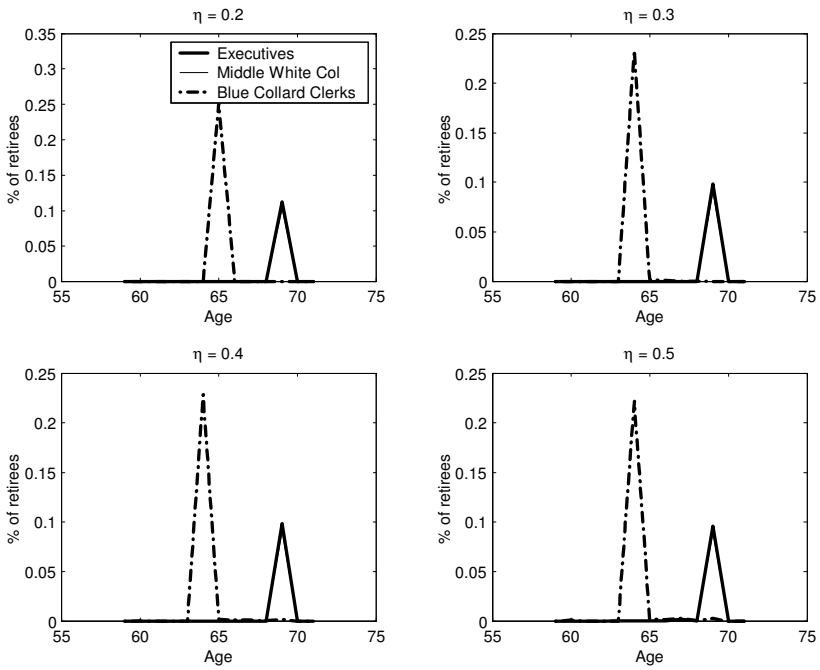


Figure 11: Distribution of retirement age of employed individuals as a function of altruism (η) (II)

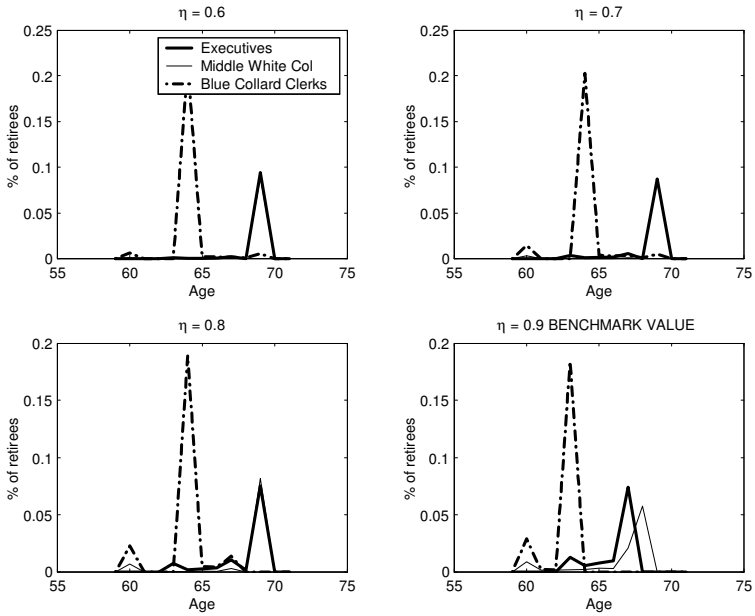
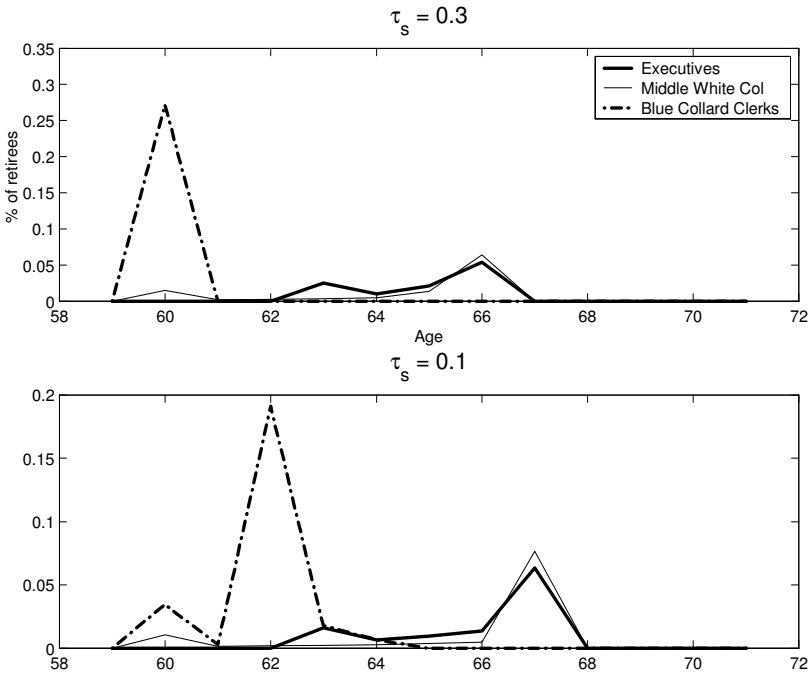


Table 12: Actuarially fair incentives and SS deficit ($\tilde{r} = 0\%$)

τ	Expected decline in Social Security Deficit (%) GR (1)	MCSNE (2)	MCSE (3)	Total (4)	Dependency ratio
0	0,0	-30,0	-23,1	-10,4	50,0
0,1	-5,2	-24,8	-21,7	-12,2	51,1
0,2	-7,5	-18,5	-18,8	-11,7	52,9
0,3	-8,7	-14,4	-14,2	-10,8	53,7
0,4	-8,0	-9,5	-9,2	-8,5	54,6
0,5	-6,4	-6,1	-4,3	-6,1	55,3
0,6	-2,9	-2,1	-2,5	-2,6	56,1
0,7	0	0	0	0	56,6

Recall that GR is the General Regime based on defined pension plans. MCSNE and MCSE are mandatory complementary schemes based on defined contribution plans. Figures in columns (1) to (4) are changes in each deficit. The benchmark SS deficit is the one computed for year 2040 without SS reforms

Figure 12: Distribution of retirement age of employed individuals ($\tilde{r} = 0\%$)



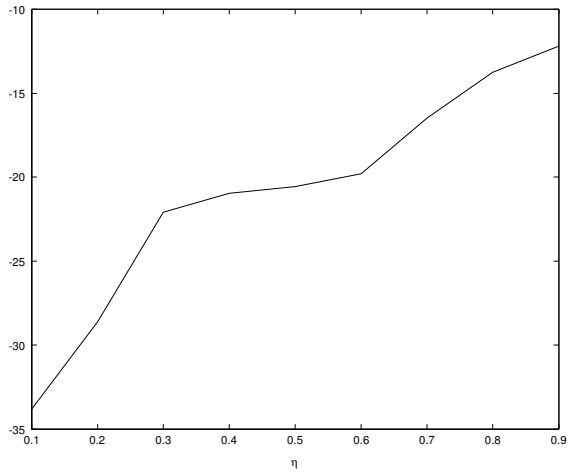
Column (1) that reports the impact of actuarially fair schemes on the GR expected deficit captures a first Laffer curve. With low values of τ, individuals have a strong incentive to delay retirement decision. However, the incentives are close to the actuarially fair value, which is, by definition, neutral for the GR deficit. In contrast, high values of τ increases the contributions collected by the GR. Nevertheless, employees are given only a small incentive to work beyond the full rate. With $\tau = 0.7$, all social groups retire as soon as they reach the full rate : the distribution of retirement age mimics figure 3. Individuals do not respond to incentives. The change in Social Security provisions does not improve the expected budget deficit.

The Laffer curve yields an incentive rate τ^* that maximizes the reduction in the GR deficit. Table 12 suggests $\tau^* = 0.3$ that leads to a 8.7% decrease in the expected deficit. The associated distribution of retirement age is displayed in the upper panel of figure 12.

A second Laffer curve appears when we consider the total change in Social Security deficit (column (4) of table 12). The maximum point of this second Laffer curve is actually $\tau^* = 0.1$ with a 12% decrease in the total Social Security deficit. With a lower tax on continued work (τ decreases), as more individuals delay retirement, the deficit of both contribution-based complementary schemes declines. The combination of the first Laffer curve and the growing fall in MCSNE and MCSE deficit yields the second Laffer curve. The subsequent retirement age across social groups is displayed in the lower panel of figure 12.

If Social Security benefits were more flexible, individuals are expected to take advantage of incentive schemes. It appears that wealth plays a key role in retirement decisions. Indeed, the

Figure 13: Expected reduction in total SS deficit as a function of altruism (η)



distribution of retirement age is more spread out, which mirrors wealth heterogeneity. On figure 12, for instance, the wealthiest employed executives retire earlier, the others accept to postpone retirement either to get an increased pension when they retire or to increase their saving in order to insure their off-spring against bad luck in the random drawing of social status at the beginning of life. Given the high degree of altruism in the model, the effect of the incentive scheme is weak. As a result, the maximum of the Laffer curve is reached for a low value of τ, the expected reduction in Social Security deficit does not top 12%. As shown by figure 13, lower altruism yields more significant decrease in the total Social Security deficit. The high value of altruism considered in the benchmark calibration (in order to match the French ratio of bequest over financial holding) penalizes the efficiency of incentive schemes.

Finally, in the benchmark scenario, the impact of incentives might appear weak. Nevertheless, official estimates (COR [2001]) forecast a decline in unemployment and pre-retirement rates for old workers. The larger the labor force participation rate (LFPR), the greater the impact of incentive schemes on the Social Security deficit. As all experts disagree about the magnitude of the phenomenon, we consider a more favorable hypothesis on the labor market : the unemployment and pre-retirement probabilities are divided by 4, consistently with a middle scenario in official estimates. As shown by table 13, the Laffer curve shifts up : the effectiveness of incentive schemes is larger, we reach a decline of the total Social Security deficit of 16%, instead of 12% in the benchmark scenario. Furthermore, the dependency ratio amounts to 47% instead of 51%. However, as τ^* remains low ($\tau^* = 10\%$), the total reduction in Social Security deficit does not top 16%.

6.2 Incentives and financial proceedings

In order to improve the efficiency of incentive schemes, we propose to introduce a careful "portfolio management at the margin" into the PAYG system. Such a reform combined with the incentive programs does not modify the intergenerational solidarity inherent to the PAYG system.

Table 13: Laffer Curve when unemployment and pre-retirement rates are lower

τ	Benchmark		Higher LFPR	
	Total change in SS deficit	Dependency Ratio	Total change in SS deficit	Dependency Ratio
0	-10,4	50,0	-13,5	45,8
0,1	-12,2	51,1	-16,3	47,7
0,2	-11,7	52,9	-15,3	50,6
0,3	-10,8	53,7	-14,0	52,0
0,4	-8,5	54,6	-10,5	53,4
0,5	-6,1	55,3	-6,8	54,5
0,6	-2,6	56,1	-1,2	55,8

Table 14: Actuarially fair Incentives

$\tilde{r} = 5\%$	$\lambda_2^*(z+1) - \lambda_2^*(z)$								
$z+1$	61	62	63	64	65	66	67	68	69
Executives	0	0	5,85	6,48	7,19	7,98	8,89	9,91	11,08
Middle White Collars	6,14	6,85	7,65	8,56	9,6	10,81	12,19	13,8	15,65
Blue Collars, Clerks	6,18	6,94	7,81	8,86	10,03	11,39	12,97	14,83	17,02

With incentive schemes described in the last section, when someone delays retirement, the General Regime immediately shares the additional taxes among the current generation of retirees. Alternatively, the GR could invest the additional receipts (collected taxes on wages and pension not paid to workers who delay retirement) on the financial markets on risk-free bonds whose return is $\tilde{r} > 0$. The return on financial investment helps finance the increase in the GR pension of the individuals who accepted to defer retirement. This corresponds to a mandatory funded GR system at the margin by which the GR has access to an higher rate of return.

This section measures the sensitivity of our results to the rate of return considered. As can be seen from table 14, with a higher interest rate ($\tilde{r} = 5\%$), incentives increase: as GR collects financial returns, the General Regime (GR) can increase the incentives to work beyond the full rate.

The Laffer curve presented in table 15, column (4), reaches an optimum with $\tau^* = 0.4$: with a return on financial investment, the Social Security grants a lower fraction of the actuarially fair scheme in order to entice individuals to delay retirement. In addition, the maximum decline in the total expected Social Security deficit amounts to -30% versus -12% when $\tilde{r} = 0\%$.

Figure 14 displays the distribution of retirement choices for the maximum point of the Laffer curve. Due to larger incentives, unskilled workers, who represent 50% of the labor force, significantly delay retirement until the age of 65 versus 63 on figure 12.

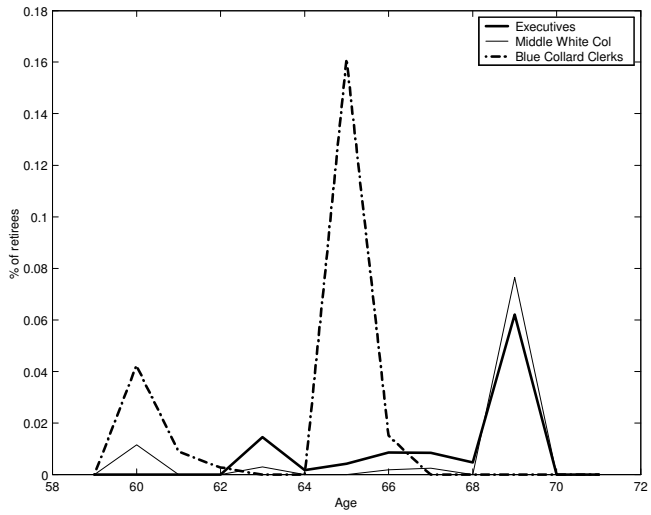
Incentive schemes along with this portfolio management at the margin could indeed substantially help fund the expected Social Security deficit while preserving the intergenerational solidarity of the PAYG system.

Table 15: Actuarially fair incentives and SS deficit ($\tilde{r} = 5\%$)

	Expected Decline in Social Security deficit (%)				
	GR	MCSNE	MCSE	Total	Dependency
τ	(1)	(2)	(3)	(4)	Ratio
0	0	-49,9	-40,7	-17,7	45,6
0,1	-8,6	-49,2	-39,9	-22,7	45,7
0,2	-16,2	-46,1	-38,8	-26,5	46,4
0,3	-22,3	-42,4	-36,9	-29,2	47,3
0,4	-26,4	-37,8	-34,0	-30,2	48,3
0,5	-21,9	-26,4	-22,2	-23,0	51,3
0,6	-16,8	-16,9	-15,0	-16,6	53,3
0,7	-10,7	-8,7	-8,1	-9,8	54,8

Recall that GR is the General Regime based on defined pension plans. MCSNE and MCSE are mandatory complementary schemes based on defined contribution plans. Figures in columns (1) to (4) are changes in each deficit. The benchmark SS deficit is the one computed for year 2040 without SS reforms

Figure 14: Distribution of retirement age of employed individuals at the maximum point of the Laffer Curve, $\tau = 0.4$ ($\tilde{r} = 5\%$)



7 Conclusion

Our quantitative exercise relies on French data since France exemplifies a PAYG system in which there is little choice in the retirement decisions. Incentive program introduces a contributive flavor in the French defined pension plan. We find that individuals are responsive to incentive programs: all social groups accept to postpone retirement providing they are given enough incentives. The Social Security faces an trade off between giving enough incentives to make individuals actually put off retirement and giving little increase in Social Security provisions in order to help finance the expected deficit of the PAYG system. This trade-off is captured by a Laffer curve.

We show that, once incentives allowing to bring retirement decisions closer to the optimum are taken into account, the interplay between wealth and the elderly's labor participation becomes stronger. It is then crucial to carefully model wealth accumulation motives in order to gauge the effect of the lengthening of retirement age. In this paper, we particularly focus on the altruism motive in presence of intergenerational social mobility and borrowing constraints. It appears that high degrees of altruism along with social mobility penalize the efficiency of incentive schemes. Finally, in order to enhance the ability of incentive programs to finance the expected Social Security deficit, the additional taxes collected in case of delayed retirement should be invested on the financial market. In the most favorable scenario, up to 30% of the expected deficit is financed through incentives.

We assumed in the paper that the General Regime of the Social Security is facing a surviving probability captured by the average mortality observed in the population. However, it is fairly intuitive that individuals who consider themselves in a better health condition are enticed to delay retirement, which could increase the surviving probability of workers who actually postpone retirement. As a result, there would be a risk of deepening the Social Security deficit. In order to take into account this adverse selection phenomenon, one should implement incentive schemes that remedy this asymmetric information issue. This is left for future research.

Appendix

A Optimizing programs

Decision rules are solution to the following optimizing programs

1. Choice when young ($s \in J$)

   At the beginning of her life cycle, choices are limited to the choice of optimal savings that solve the following program

$$\begin{aligned} v(a,J) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{\pi_{JJ}v(a',J) + (1-\pi_{JJ})v(a',A)\right\} \\ (1+g)a' &= (1+r)a + w(J) - \Theta(w(J)) - c \\ a' &\geq 0 \end{aligned}$$

   where v denotes the household's value function, r and w the interest rate and the wage. Finally, $\Theta(w(J))$ embodies taxes used to finance the pay-as-you-go system. Only the

share paid by employees is introduced in households' budget constraint. Taxes depend in a non-linear fashion on the level of wages through contributions collected by mandatory complementary schemes, while proportional taxes are used to finance the general regime. Given the specification of the utility function, the discount rate becomes $\tilde{\beta} = \beta/(1+g)^{(1-\eta)(1-\tilde{\sigma})}$. Taxes finance the retirement system (general regime and complementary schemes):

$$\Theta(w) = \underbrace{\theta w}_{\text{General Regime}} + \underbrace{\theta_1 \min(w, Ceiling^{SS}) + \theta_2 \max(0, w - Ceiling^{SS})}_{\text{Complementary schemes}}$$

where

$$\theta_1 = \begin{array}{l} \text{Under } Ceiling^{SS} \\ \theta^{MCSNE} c_1^{MCSNE} \end{array} \tag{15}$$

$$\theta_2 = \begin{array}{l} \text{Above } Ceiling^{SS} \\ \left\{ \begin{array}{ll} \theta^{MCSNE} c_2^{MCSNE} & \text{if non executive (blue collars and middle employees)} \\ \theta^{MCSE} c_2^{MCSE} & \text{if executive} \end{array} \right. \end{array} \tag{16}$$

2. Choice when adult ($s \in A$)

   When adult, the individual faces employment risks at age 59. At this age, individuals face 3 possible states : employed (e), unemployed (u) and pre-retirement (p). Transition to these states obey exogenous probabilities denoted by π_e, π_u, π_p. Employment probabilities are specific to each social category and given by matrix Π. Optimal choices are thus solution to:

$$\begin{aligned} v(a, A) &= \max_{c \geq 0} u(c, l) \\ &\quad + \tilde{\beta} \left\{ \begin{array}{l} \pi_{AA} v(a', A) \\ +(1-\pi_{AA}) \left[\begin{array}{l} \pi_e v(a', \{e, M59\}) + \pi_u v(a', \{u, M59\}) \\ +\pi_p v(a', \{p, M59\}) \end{array} \right] \end{array} \right\} \\ (1+g)a' &= (1+r)a + w(A) - \Theta(w(A)) - c \\ a' &\geq 0 \end{aligned}$$

   As an adult, the individual determines his consumption as a function of her expectations of future income.

3. Choice when mature ($s \in M$)

   From the age of 59 on, individuals have the legal right to retire the following year. Each individual compares the future value of being a retiree and the future value of remaining in her current state (employed, pre-retired or unemployed). Mortality risks also intervene in this choice, the probability of death being $(1 - \pi_{zz'})$.

   Optimal choices are solutions to the following program

   (a) age $z = \{59, ..., 69\}$

- If the individual is employed at age z

$$\begin{aligned} v(a,\{e,z\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{\begin{array}{l}(1-\pi_{zz'})\Phi\eta v(a',J)\\ +\pi_{zz'}\max[v(a',\{e,z'\}),v(a',\{R,z'\})]\end{array}\right\} \\ (1+g)a' &= (1+r)a + w(z) - \Theta(w(z)) - c \\ a' &\geq 0 \end{aligned}$$

When an individual dies, he gives birth to a Young whose social group is determined by the mobility matrix Φ.

- If the individual is unemployed at age z

$$\begin{aligned} v(a,\{u,z\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{\begin{array}{l}(1-\pi_{zz'})\Phi\eta v(a',J)\\ +\pi_{zz'}\max[v(a',\{u,z'\}),v(a',\{R,z'\})]\end{array}\right\} \\ (1+g)a' &= (1+r)a + \theta^u w(z) - c \\ a' &\geq 0 \end{aligned}$$

where θ^u denotes the replacement ratio associated with unemployment benefits. Notice that unemployed people do not contribute to the system. Unemployment insurance pays for unemployed people.

- If the individual is pre-retired at age z

$$\begin{aligned} v(a,\{p,z\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{\begin{array}{l}(1-\pi_{zz'})\Phi\eta v(a',J)\\ +\pi_{zz'}\max[v(a',\{p,z'\}),v(a',\{R,z'\})]\end{array}\right\} \\ (1+g)a' &= (1+r)a + \theta^p w(z) - c \\ a' &\geq 0 \end{aligned}$$

where θ^p denotes the replacement ratio associated with pre-retirement. As unemployed workers, pre-retired people do not contribute to the pay-as-you-go system. The State as well as unemployment insurances pay for pre-retired people.

- If retiree at age z

For these individuals, retirement has been chosen. The only choice they face is their consumption profile and the optimal amount of financial asset they want to give to their children, given the social mobility matrix. Their behavior are solutions to the following program:

$$\begin{aligned} v(a,\{R,z\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{(1-\pi_{zz'})\Phi\eta v(a',J) + \pi_{zz'}v(a',\{R,z\})\right\} \\ (1+g)a' &= (1+r)a + \omega(z) - c \\ a' &\geq 0 \end{aligned}$$

where $\{R,z\}$ denotes that the individual is a retiree of age z.

(b) An individual of age 69

Employed, Unemployed and Pre-retired people automatically become retiree. Decisions rules are the following:

- If employed at age 69

$$\begin{aligned} v(a,\{e,69\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{(1-\pi_{zz'})\Phi\eta v(a',J) + \pi_{zz'}v(a',R)\right\} \\ (1+g)a' &= (1+r)a + w(69) - \Theta(w(69)) - c \\ a' &\geq 0 \end{aligned}$$

- If unemployed at age 69

$$\begin{aligned} v(a,\{u,69\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{(1-\pi_{zz'})\Phi\eta v(a',J) + \pi_{zz'}v(a',R)\right\} \\ (1+g)a' &= (1+r)a + \theta^u w(69) - c \\ a' &\geq 0 \end{aligned}$$

- If pre-retired at age 69

$$\begin{aligned} v(a,\{p,69\}) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{(1-\pi_{zz'})\Phi\eta v(a',J) + \pi_{zz'}v(a',R)\right\} \\ (1+g)a' &= (1+r)a + \theta^p w(69) - c \\ a' &\geq 0 \end{aligned}$$

(c) If retirement occurs at age 70
The individual determines her consumption behavior by solving:

$$\begin{aligned} v(a,R) &= \max_{c\geq 0} u(c,l) + \tilde{\beta}\left\{(1-\pi_{zz'})\Phi\eta v(a',J) + \pi_{zz'}v(a',R)\right\} \\ (1+g)a' &= (1+r)a + \omega(R) - c \\ a' &\geq 0 \end{aligned}$$

B The French retirement system

B.1 Benefits from the basic General Regime (GR)

We present the rules of the basic regime applied to the people who retire before year 2008. The early retirement age is 60 years old. The pension depends on three elements: the reference wage, the pension rate and the numbers of quarters of contribution. The pension is based on the following formula for an individual of age z:

$$\omega^{basic}(z) = \frac{d}{150} \times w^{ref}(z) \times \phi \tag{17}$$

where d stands for the number of contributing quarters to the General regime. Periods of unemployment or pre-retirement are included in d since the GR receives transfers from the unemployment insurance services. The latter contribute to the PAYG system on behalf of unemployed and pre-retired. These payments are taken into account when computing the balance of the GR system (section 3.4).

- The wage $w^{ref}(z)$ refers to the average annual gross wage of the best 10 years of one's career. Wages are truncated to the Social Security ceiling that prevailed each year such

that the reference wage is

$$w^{ref}(z) = \frac{1}{N}\sum_{n=1}^{10} Min(w_n(z), \text{Ceiling}^{SS}) \tag{18}$$

where $w_n(z)$ and Ceiling^{SS} denote the wage of the best $N = 10$ years and the Social Security ceiling. The presence of the Social Security ceiling limits the replacement ratio for executives whose wages are higher than Ceiling^{SS}.

- The pension rate ϕ equals at most 50%. An individual is eligible to receive this "full rate" ($\phi = 0.5$) once she contributed 150 quarters to the general regime or at the age of 65 whatever the number to quarters of contribution. If retirement occurs before one of these conditions is met, the individual faces a reduced pension rate equalled to 50% minus 1.25% per quarter missing to reach either the age of 65 (260 quarters) or 150 contributing quarters. ϕ is written as

  $$\phi = 0.5 - 0.0125 \times \max\{0, \min[260 - z \times 4, 150 - d)]\}$$

  Our proxy for d is based on the difference between the current age z and the age of the end of education.

Formula (17) provides a large incentive to wait until the individual reaches the full rate before claiming the Social Security benefits. Indeed, retiring before 150 quarters of contribution implies not only a reduced pension rate ϕ but also a lower share of the reference wage included in the pension (through the "proratization" term $\frac{d}{150}$ in equation (17)).

In 1993, the Balladur reform increased the required number of years of contributing years from 150 quarters to 160 quarters without affecting the "proratization" term. Equation (17) then becomes

$$\begin{aligned} \omega^{basic}(z) &= \min\left(1, \frac{d}{150}\right) \times w^{ref}(z) \times \phi \\ \phi &= 0.5 - 0.0125 \times \max\{0, \min[260 - z \times 4, \mathbf{160} - d)]\} \end{aligned} \tag{19}$$

Moreover, the reference wage is an average of the best $N = 25$ years, which tends to lower $w^{ref}(z)$ for the people who went through unemployment episodes during their career. This reform is implemented so gradually that its full impact on retirement age will be observed only in year 2008. Subsection 4.2 checks that the model replicates the distribution of retirement age observed in the 1990s. We then attempt to predict the consequences of the Balladur reform on retirement decisions.

With incentive schemes, equation (19) becomes

$$\begin{aligned} \omega^{basic}(z) &= \frac{d}{150} \times w^{ref}(z) \times \phi \\ \phi &= 0.5 - 0.0125 \times \max\{0, \min[280 - z \times 4, 160 - d)]\} \\ &\quad + \lambda_2^*(z) \max(0, d - 160) \end{aligned}$$

B.2 Benefits from complementary schemes : MCSNE and MCSE

Complementary schemes rely on defined contribution plans. "Points" are purchased by each individual during her career. Each year, a fixed proportion of the wage τw is devoted to the purchase of these points. One euro of earning yields $1/p^{MCSNE}$ points. The contribution rate τ is fixed by MCSNE and MCSE each year. At the age of retirement, points are converted into euros of pension by multiplying the number of points by a coefficient denoted v_d. The pension at age z then amounts to

$$\omega^{MCSNE}(z) = points(z) \times v_d \times penalty(z) \tag{20}$$

where $points(z) = \sum_{i=1}^{z} \frac{c(i)w(i)}{p^{MCSNE(i)}}$denotes the total number of points accumulated throughout the years, v_d the value of each point at the date of retirement. If one chooses to retire before contributing 150 quarters (160 quarters under the Balladur reform) to the system or before the age of 65, penalties ($penalty(z)$) are applied to the pension that then decreases by approximately 4% each year missing to reach age 65. For non executives, contributions are collected by MCSNE. Different contribution rates are applied to the part of the wage below and above the Social Security ceiling. For executives, MCSNE (respectively MCSE) collects the contribution for the part of the wage below (respectively above) the Social Security ceiling.

Finally, MCSNE and MCSE introduce a wedge between the contribution rate paid by workers (c') and the contribution rate that grants them points (c). In the data, $c' > c$: by imposing this discrepancy between the tax paid and tax giving the right to points, complementary schemes anticipate the expected deficit associated with the future demographic change. MCSNE and MCSE apply different wedges. Let $\frac{c'_{MCSNE}}{c_{MCSNE}} = \theta^{MCSNE}$ (respectively $\frac{c'_{MCSE}}{c_{MCSE}} = \theta^{MCSE}$) be the wedge used by MCSNE (respectively MCSE) for the part of the wage below and above the Social Security ceiling. θ^{MCSE} and θ^{MCSNE} are endogenously determined at the stationary equilibrium.

B.3 Calibration of the French pension system

The Social Security ceiling used to compute the pensions paid by the general regime and complementary schemes is set to its 1994 value, i.e. 156720Frs a year.

The calibration of parameters of complementary schemes in equations (20), (15) and (1) are given by tables 16 and 17. These values correspond to the ones prevailing in 1994 and were provided by MCSNE and MCSE. Today 2/3 of the contributions to the complementary schemes are paid by employers. We assume that this ratio is not modified.

Table 16: MCSNE : ARRCO complementary scheme

c_1^{ARRCO}	c_2^{ARRCO}	p^{ARRCO}	v_d^{ARRCO}
0,04	0,1	22,4	2,455

Table 17: MCSE : AGIRC complementary scheme

c_2^{AGIRC}	p^{AGIRC}	v_d^{AGIRC}
0,12	19,52	2,303

Table 18: Penalties

age	55	56	57	58	59	60	61	62	63	64
penalty	0.43	0.50	0.57	0.64	0.71	0.78	0.83	0.88	0.92	0.96

Table 18 presents the value of penalties (equation (20)).

At the stationary equilibrium, the wedges θ^{MCSNE} and θ^{MCSE} endogenously adjust to balance the budget of complementary schemes.

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