Inequality and Social Security Reforms

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Abstract

This paper develops a quantitative markovian overlapping generations model with altruistic individuals in order to analyze the long-run distributional implications of demographic changes and pension reform in France. For simplicity, the only risks individuals face throughout their lifetime are idiosyncratic: a worker faces a potential loss of wage income; a retiree faces an uncertain time of death. Financial markets are incomplete. Whereas a more funded system deteriorates the relative situation of the retirees, huge financial heterogeneity in a generous pay-as-you-go system explain why the increase in the proportional labor tax is relatively badly absorbed by low-productivity workers, leading to an increase in welfare inequality. We show that the very popular idea that a more funded system would ineluctably lead to more well-being inequalities can be justified by only focusing on inequality of positions in the case of a particularly low interest rate.
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JEL classification: D31, E62, H31

1 Introduction

Demographic changes across the developed world will put strain on pay-as-you-go (PAYG) pension systems. This has renewed the political debate on the optimal system between funded and unfunded schemes. On theoretical grounds, it is well-known that in dynamically efficient economies, funded pension system, where individuals accumulate their own fund, should be favored. Beyond the empirical relevance of this situation, there is however generally no Pareto improving way of making a transition from an unfunded system to a funded one. This creates some scepticism about the practicability of such a reform. Moreover, PAYG systems redistribute not only income across generations, but also within generations as the benefits accruing to an individual are not proportional to the taxes he pays. Under incomplete financial markets, they can then provide risk sharing for risk averse agents submitted to labor earnings uncertainty. All these arguments explain why the debate is far to be closed on the efficiency ground despite the huge literature devoted to this question.

Beyond the efficiency question, it appears that the degree of inequality implied by the different pension systems is at the heart of the public debate. If the PAYG systems has received so much support, it is because it is considered as inequality-reducing relatively to a more funded system. This explains why proposals for social security reforms attempt to address both the issues of equity and efficiency in addition to the solvency issue. For instance, Huggett and Ventura [1999] focus on the distributional effects of social security reforms[1], each under PAYG financing and they show that eliminating all redistributive schemes benefits to agents with high abilities at birth at the expense of low abilities agents. However, Fuster [1999] shows that PAYG systems may lead to more inequality of wealth when altruism is considered: even a progressive social security system can lead to a higher dispersion in the distribution of wealth. In a model with altruism only rich individuals save for bequests and the intergenerational transfers organized by the social security system can lead to a less egalitarian wealth distribution.

This paper develops a quantitative overlapping generations model with altruistic individuals that is useful for analyzing the long-run distributional implications of demographic changes and pension reforms in France. We quantify the inequality implications of different policy experiments designed to cope with the aging of the population due to the increase in the expected life time. We consider two *scenarii*, all under PAYG financing: firstly an increase in the labor tax rate with a constant replacement rate, and secondly, a lowering of the latter with unchanged labor tax rate.

In this paper, we take into account the importance of altruism emphasized by Fuster [1999]. However, we depart from Fuster [1999] by introducing two important features of existing economies which could have important quantitative distributive implications when social security reforms due to demographic changes are considered. Firstly we escape from the extreme altruism vision underlying the dynastic framework considered by Fuster [1999]: we aim at calibrating the degree of altruism consistent with observed bequest behavior. We thus adopt in the lines of Castaneda, Diaz-Gimenez, and Rios-Rull [1998] a markovian representation by introducing constant probabilities of transition into the different life-cycle stages. This framework allows to take into account altruism in a more funded way than in the traditional overlapping generation model[2] and it is flexible enough to depart from the dynastic case. Secondly we consider that retirees face an uncertain time of death in an environment where there are borrowing constraints and market failures in the private provision of annuities. Taking into account this risk is important for any distributive implication comparison between PAYG and more funded system.

The theoretical framework is built to quantify the traditional arguments

[1]They investigate social security reforms with a two-tier structure. This first tier is a defined-contribution pension scheme, whereas the second tier guaranties a minimum floor income in retirement.

[2]See DiNardi [1999] for an application on the wealth inequality of intergenerational links in such a traditional framework.

in disfavor of a more funded pension system. We calibrate the model on the French economy. For comparing the different reforms, we focus on consumption inequality. We will mention wealth and income inequality only insofar as they allow to understand the former. Does a PAYG scheme reducing the rate of replacement naturally lead to more inequality? The redistributive effects of the PAYG system are automatically lowered by reducing the share of the state pension which embodies redistribution mechanisms. Moreover, individual accumulation is not obligatory, escaping from the guardian principle of the PAYG system. Finally, as noted above, actuarially-fair annuity contracts are not available whereas PAYG system insures agents against the risk of death. However, the more heterogenous asset distribution in a generous PAYG system could explain why the increase in the proportional labor tax may be absorbed differently by agents, leading to an increase in welfare inequality. Wealth heterogeneity and liquidity constraints may magnify the welfare inequality in a PAYG system. Our objective in this paper is to give a quantitative assessment on the relative importance of these opposite effects.

Our approach of inequality is two-fold. We firstly adopt a cross-section approach of inequality that we call inequality of position. Note that this is the way empirical studies evaluate the degree of inequality. This latter will be measured by the means of the inter-decile ratio and by the Gini index, computed on the stationary distribution. However these measures are not informative of the intertemporal welfare heterogeneity which may be considered as a more relevant measure of inequality. Hence, we secondly analyze intertemporal welfare-based inequality measures, focusing on what we call the inequality of perspectives.

We first study the effect of pensions reforms on consumption inequality without allowing price adjustment before turning to general equilibrium. This is both for didactic reasons, because it isolates the importance of factor prices adjustment, and because empirically this question remains an open question. The French economy is generally considered as a small open economy. But as most developed countries face the same demographic expectations it is difficult to consider the international interest rate as constant. In a context of financial globalization, the different demographic processes in other world areas leave definitely open the question of the expected evolution of the international interest rate. One way to deal with this question is to build a world overlapping generations general equilibrium model taking into account the different demographic dynamics (see for instance Ingenue [2002]). However, it is then difficult to present a detailed and informative analysis of the pension reforms implications on inequality. This is why we prefer to present both the partial equilibrium and the general equilibrium outcomes in a coherent framework calibrated on French economy.

We show that each reform has its own drawbacks. Asset accumulation should be partly obligatory and based on actuarially-fair annuity contracts. PAYG system should introduce an age-dependent labor tax taking into account the efficiency rise during the working life-time (Hubbard and Judd [1987]). The inequality of position criterion particularly reveals the dramatic implications of the risk of life embodied in a more funded system for retirees who overlive their expected time of death, whatever the factors price adjustment hypothesis considered. Reform leaving the replacement rate unchanged could also lead to more inequality, due to the presence of liquidity constrained agents. The scale of this effect crucially depends on the intensity of prices adjustments: it declines with the increase of wages following the decrease of the equilibrium interest rate due to the aging of the population. We also show that adopting an inequality of perspectives criterion is another way to temper the bias in favor of PAYG system when inequality is put forward. To sum up, a more funded pensions system does not necessarily lead to more inequalities if the prices adjustments are weak or if an inequality of perspectives approach is favored.

In a first section, the model is presented. Secondly, after calibrating it, we check whether our setup is able to replicate some aggregate features and the main distributional facts of the French economy. In the last section, we then simulate different policy experiments designed to cope with the aging of the population due to the increase in the expected life time.

2 The 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, as in Aiyagari [1994]', life cycles features are also considered. Following here Castaneda, 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.

2.1 Population dynamics and employment opportunities

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

2.1.1 Population dynamics

At each period, some households are born and some households die. We assume that the measure of the newly-born is growing at a rate of n. They are born as workers. With a certain probability, they can retire. Upon retirement, they can die, again with a certain probability.

In order to take into account a typical wage life-cycle profile, we assume that the worker population can be divided into three classes of age, the young, the experienced and the old workers respectively denoted $C1$, $C2$ and $C3$. 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 $1+x_1$. When an experimented worker becomes an old worker, his efficiency is multiplied by $1+x_2$, with $x_1 < x_2$. Given to the concentration of the retirement age, only old workers may become retired.

Each individual is born as a young worker. The probability of remaining a young (experienced) worker the next period is π_{11} (π_{22}). Conversely, the probability of becoming an experienced (old) worker is $1-\pi_{11}$ ($1-\pi_{22}$). Conditional on being an old worker in the current period, the probability of retiring is $1-\pi_{33}$. We also consider three classes of retirement in order to take into account the increasing rate of mortality with age. In the first class of retirement ($C4$), an individual cannot die. With a probability $1-\pi_{44}$, the young retiree is a middle-aged retiree. This latter class of retirees ($C5$) has a positive probability of dying π_{51}. These individuals can also be old retirees in the next period with a probability $1-\pi_{55}-\pi_{51}$. Retirees of the last class of age ($C6$) have a probability of surviving to the next period given by π_{66}.

The matrix $\mathcal{P}$ governing the age markov-process is given by:

		$t+1$					
		$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
	$C1$	p_{11}	$1-p_{11}$	0	0	0	0
	$C2$	0	p_{22}	$1-p_{22}$	0	0	0
t	$C3$	0	0	p_{33}	$1-p_{33}$	0	0
	$C4$	0	0	0	p_{44}	$1-p_{44}$	0
	$C5$	p_{51}	0	0	0	p_{55}	$1-p_{55}-p_{51}$
	$C6$	$1-p_{66}$	0	0	0	0	p_{66}

Let N_t^{Ci}, for $Ci = C1, ..., C6$, the number of people in each cohort. In order to get a stationary growth rate of the population and a constant relative weight of the cohorts, the population inflow is fixed each period at $(1-p_{11}+n)N_t^{C1}$. The sub-population dynamics is then given by:

$$N_{t+1}^{C1} = (1-p_{11}+n)N_t^{C1} + p_{11}N_t^{C1} \tag{1}$$

$$
\begin{aligned}
N_{t+1}^{C2} &= (1-p_{11})N_t^{C1} + p_{22}N_t^{C2} & (2)\\
N_{t+1}^{C3} &= (1-p_{22})N_t^{C2} + p_{33}N_t^{C3} & (3)\\
N_{t+1}^{C4} &= (1-p_{33})N_t^{C3} + p_{44}N_t^{C4} & (4)\\
N_{t+1}^{C5} &= (1-p_{44})N_t^{C4} + p_{55}N_t^{C5} & (5)\\
N_{t+1}^{C6} &= (1-p_{55}-p_{51})N_t^{C5} + p_{66}N_t^{C6} & (6)
\end{aligned}
$$

where equation (1) implies that the young workforce grows at the gross rate $1+n$. At stationary equilibrium, equations (1)-(6) imply that:

$$
\begin{aligned}
\frac{N^{C2}}{N^{C1}} &= \frac{1-p_{11}}{1+n-p_{22}}\\
\frac{N^{C3}}{N^{C1}} &= \frac{1-p_{22}}{1+n-p_{33}}\\
\frac{N^{C4}}{N^{C1}} &= \frac{1-p_{33}}{1+n-p_{44}}\\
\frac{N^{C5}}{N^{C1}} &= \frac{1-p_{44}}{1+n-p_{55}}\\
\frac{N^{C6}}{N^{C1}} &= \frac{1-p_{55}-p_{51}}{1+n-p_{66}}
\end{aligned}
$$

Since all these ratio are fixed, all the cohorts grow at the gross rate $1+n$.

2.1.2 Employment opportunities

There are three components in the real wage : a deterministic exogenous productivity trend growing at a rate of γ, the experience component the profile of which has been described above, and an idiosyncratic risk. Each individual faces each period of his life an idiosyncratic random disturbance that determines his rank in the employment opportunities set (his "social class") for a given age. These disturbances are independent and identically distributed across households, and they follow a finite state Markov chain with conditional transition probabilities given by

$$\psi(\epsilon'|\epsilon) = Pr\{\epsilon_{t+1} = \epsilon'|\epsilon_t = \epsilon\}$$

where $\epsilon, \epsilon' \in \mathcal{E}$. We assume that this employment opportunities Markov process is independent from the age Markov-process. We also assume that there is no mobility when individuals are retired. Moreover, conditionally of becoming retiree, we have:

$$\psi(\epsilon'|\epsilon) = 1$$

This last assumption allows to have pension indexed on the last real wage. Finally, we assume that a newly-born household has the same productivity rank than his parents. To sum up, the idiosyncratic employment opportunities determine the relative productivity inside a given household's age-cohort. The absolute level of efficient labor units is then given by the age.

2.2 The households decision

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

$$\sum_{t=0}^{\infty} \beta^t \left\{ \sum_{s_t \in \mathcal{V}} \pi(s_t|s_{t-1}) u(C_t) + \eta\beta \sum_{s_t \in S1} \pi(s_{t+1}|s_t) V(A_{t+1}, s_{t+1}) \right\} \tag{7}$$

where the period utility function u is strictly concave, the time-discount factor verifies $\beta \in]0,1[$, the consumption C_t is positive. The variable $s_t \in S$ is a compact notation to denote the age and the employment opportunity 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 and $S1$ the subset of states conditionnaly to be a new-born.

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 both catches the degree of altruism in the economy ($\tilde{\eta}$) and the "fertility rate"[3]. Thus, $V(A_{t+1}, s_{t+1})$ denotes the expected utility of a new-born child who begins his career at the same level of the productivity ladder than his 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:

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

The stationary dynamic program. In order to define a stationary equilibrium, we divide all the variables by the gross rate of technological progress

[3] We assume that this rate is identical across agents. It is then by the ratio of the population outflows to the inflows.

$(1+\gamma)$ and by the gross rate of population $(1+n)$. Let $1+g = (1+n)(1+\gamma)$. We denote stationary consumption and wealth by

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

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 households' state variable is a 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 is the following:

$$v(a,s) = \max_{c\geq 0} u(c) + \tilde{\beta}\left\{\sum_{s'} \pi(s'|s)v(a',s') + \eta \sum_{s'\in S1} \pi(s'|s)V(a',s')\right\} \tag{8}$$

s.t.

$$(1+g)a' = (1+r)a + (1-\tau)w\nu(s) + \omega(s) - c \tag{9}$$
$$a' \geq 0 \tag{10}$$

where v denotes the households' value function, r the risk-free interest rate, whereas $\nu(s)$ denotes the efficient labor units. Finally, τ is the tax rate. Given the utility function, the modified discount rate is given by $\tilde{\beta} = \beta/(1+g)^{(1-\sigma)}$. The agents are assumed to face a liquidity constraint (see equation (10)).

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 as a function of (a, s).

2.3 Fiscal policy and social security

Social security pays pensions for a total of Ω_t to retirees. The system is financed by levying taxes on workers denoted T_t. Each period, the social security is balanced:

$$T_t = \Omega_t$$

More precisely, the social security system is financed by the proportional tax τ on labor income levied on all working people. We assume that the pensions are linked to the individual earnings histories of the workers. Nevertheless, allowing idiosyncratic history dependence in social security payments would mean sacrificing considerable tractability. Thus, for simplicity, the pensions $\omega(s)$ are indexed only on the last wage earned by workers. In order to take into account the redistributive dimension of the social security system, they are also indexed on the average wage.

$$\omega(s \in \{S4, S5, S6\}) = \rho[\tilde{\rho}\overline{w} + (1 - \tilde{\rho})w\nu(s \in S3)]$$

where ρ gives the replacement rate of a combination of the average wage $\overline{w}$ and the last wage earned by the individual $w\nu(s \in S3)$. The parameter $\tilde{\rho}$ governs the degree of the redistribution implied by the social security arrangement: a higher value of $\tilde{\rho}$ goes towards a more redistributive pensions system. As it is showed in the section devoted to the calibration, this linear function allows to match some crucial stylized facts concerning the distribution of earnings in France.

2.4 Definition of the equilibrium

A steady state equilibrium for this economy is a vector of price $\{w, r\}$, a household policy $\{c(a, s), a'(a, s)\}$, a pair of household value functions $\{v(a, s), V(a, s)\}$, a social security arrangement $\{\rho, \tilde{\rho}, \tau, \omega(s)\}$, a stationary distribution of household $\lambda(a, s)$ and a vector of aggregates $(K, \mathcal{A}, \Omega, T)$ such that

(i) factor prices are factor marginal productivity: $r = F'_K - \delta$ and $w = F'_N$, where δ denotes the capital depreciation rate. The production function and the aggregate efficient employment are defined by:

$$F(K, N) = AK^{\alpha}N^{1-\alpha}$$

$$N = N^{C1}\sum_{s \in S1}\nu(s) + N^{C2}\sum_{s \in S2}\nu(s) + N^{C3}\sum_{s \in S3}\nu(s)$$

(ii) Given the vector of price and the social security arrangement, the household policy $a' = g(a, s)$ and $c = f(a, s)$ solves the decision problem described by (8) s.t. (9) and (10).

(iii) the utility of a newly-born household $V(a, s)$ is the same as that of a retiree-age household $v(a, s)$.

(iv) The distribution of probability $\lambda(a, s)$ is a stationary distribution associated with $(a' = g(a, s), \pi(s'|s))$ such that:

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

(v) The social security budget constraint is satisfied $\Omega = T$, *i.e.*:

$$\sum_{s \in \{S4,S5,S6\}} N^s \omega(s) = \sum_{s \in \{S1,S2,S3\}} N^s \tau w \nu(s)$$

(vi) The aggregate supply of capital $\mathcal{A}$ equals the demand of capital K:

$$K = \mathcal{A}$$

where the total amount of supply is obtained by aggregating over households:

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

3 Calibration and quantitative evaluation

3.1 Calibration of the model

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.

The demographic regime. Following Charpin [1999], the annual growth rate of the population is fixed at 0.65%. The transition matrix Π governing the demographic structure is calibrated so that the expected duration of the working life is 40 years, whereas the retirement period lasts in expectation 20 years. At stationary equilibrium, this matches the fact that the support ratio between retirees and workers is equal to 0.41 in the France of the 1990's.

Beyond the expected duration of these two main sub-periods of the life cycle, the expected life time is assumed to be 15 years as young worker $(C1)$[4], 20 years as experiment worker $(C2)$ and 5 years as old worker $(C3)$. Concerning the periods of retirement, the expected life time is 4 years as young retiree $(C4)$, 11 years as middle-age retiree $(C5)$ and 5 years as old retiree $(C6)$. This strategy allows for the probability of death to increase with age. All this calibration implies a fertility rate of 1.48. The demographic

[4] All the expected durations of the classes C_i are fixed in order to get available growing experience life-cycle earnings on French data.

process is described by the following transition matrix:

$$
\begin{array}{cc|cccccc}
 & & & & t+1 & & & \\
 & & C1 & C2 & C3 & C4 & C5 & C6 \\
\hline
 & C1 & 1-\frac{1}{15} & \frac{1}{15} & 0 & 0 & 0 & 0 \\
 & C2 & 0 & 1-\frac{1}{20} & \frac{1}{20} & 0 & 0 & 0 \\
t & C3 & 0 & 0 & 1-\frac{1}{5} & \frac{1}{5} & 0 & 0 \\
 & C4 & 0 & 0 & 0 & 1-\frac{1}{4} & \frac{1}{4} & 0 \\
 & C5 & \frac{1}{7}\times\frac{1}{11} & 0 & 0 & 0 & 1-\frac{1}{11} & \frac{6}{7}\times\frac{1}{11} \\
 & C6 & \frac{1}{5} & 0 & 0 & 0 & 0 & 1-\frac{1}{5}
\end{array}
$$

Idiosyncratic labor income risk. In order to calibrate the Markov process underlying the social mobility in our model, we use information from estimations of the inter-decile wage mobility on the French labor market. We then consider ten classes of productivity (P_i). The transition probabilities between these classes were first estimated by Bourguignon and Morrisson [1987] and re-estimated more recently by INSEE [1999a] using a more recent sample (Déclarations Annuelles de Données Sociales (DADS) between 1982-1992). They are reported in table 1 and give the mobility properties for households between 1982 and 1992 for labor earnings.

Table 1: Annual transitions between deciles

	ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9	ϵ_{10}
ϵ_1	0.8735	0.0744	0.0208	0.0116	0.0033	0.0031	0.0039	0.0022	0.0040	0.0031
ϵ_2	0.0398	0.8261	0.0726	0.0378	0.0113	0.0026	0.0028	0.0037	0.0010	0.0024
ϵ_3	0.0296	0.0620	0.7860	0.1017	0.0005	0.0085	0.0068	0.0012	0.0032	0.0006
ϵ_4	0.0156	0.0128	0.0706	0.7593	0.1210	0.0053	0.0061	0.0060	0.0004	0.0029
ϵ_5	0.0116	0.0108	0.0397	0.0842	0.7477	0.0864	0.0095	0.0018	0.0078	0.0005
ϵ_6	0.0113	0.0039	0.0066	0.0002	0.1105	0.7575	0.0845	0.0177	0.0046	0.0031
ϵ_7	0.0074	0.0060	0.0019	0.0026	0.0009	0.0958	0.7822	0.0857	0.0130	0.0046
ϵ_8	0.0053	0.0015	0.0013	0.0021	0.0039	0.0347	0.0771	0.8021	0.0653	0.0068
ϵ_9	0.0032	0.0021	0.0002	0.0004	0.0001	0.0047	0.0239	0.0659	0.8640	0.0354
ϵ_{10}	0.0027	0.0005	0.0003	0.0001	0.0007	0.0015	0.0031	0.0137	0.0367	0.9406

The life cycle of labor earnings. The normalized labor efficiency of the young worker cohort is:

$\nu(s \in S1) \in [0.6393\ \ 0.7255\ \ 0.8196\ \ 0.9085\ \ 1\ \ 1.1127\ \ 1.2454\ \ 1.4443\ \ 1.8263\ \ 3.1432]$

Its range is given by the observed earnings deciles as it is documented in Piketty [1997].

The efficiency of the labor input grows with the age of the agents so that $E(\nu(s \in S2)) = (1 + x_1)E(\nu(s \in S1))$ for an experimented worker and $E(\nu(s \in S3)) = (1+x_2)E(\nu(s \in S1))$ for an old worker, with $x_2 > x_1$. Given the calibration of the pensions regime, x_1 and x_2 are calibrated so that the life cycle profile of labor earnings is reproduced (see table 2). This leads to fix x_1 at 0.3 and x_2 at 0.39.

Table 2: Life-cycle profile of labor earnings

	$C1/R$	$C2/R$	$C3/R$
earnings ratio	0.95	1.23	1.32

These statistics are computed using the data reported in INSEE [1999b]. The reference year is 1996. R denotes the average earnings over all the retirees.

Preferences and technology. Following Charpin [1999], the gross rate of the technological progress is fixed 1.02. Concerning the preferences, we choose, following Attanasio, Banks, Meghir, and Weber [1999] and Cooley and Prescott [1995] the following values: $\sigma = 1.5$ and $\beta = 0.96$.

The interest rate r and the coefficient measuring the altruism are such that the capital-output and legs-capital ratios predicted by the model matches their empirical counterparts (respectively 2 and 1.4%, see Arrondel and Laferrère [1996]). Thus we obtain $r = 5.75\%$ and $\tilde{\eta} = 0.6$. At general equilibrium, we deduce the implied value of A in the production function, given a standard calibration of the capital share α and the depreciation rate δ, respectively at 0.36 and 0.08. When we compute the general equilibrium for the 2040 demographics, we keep A constant in order to find the interest rate r and the real wage w.

Social Security Arrangement. Finally, we calibrate the pensions system in order to match two main stylized facts: *(i)* the ratio between the average of the real wages and the average of the pensions is equal to 1.15 (see Charpin [1999]), *(ii)* the ratio between the first decile of pensions and the last decile is equal to 4.2 (see Atkenson, Glaude, Olier, and Piketty [2001]). This leads to fix ρ at 0.757 and $\tilde{\rho}$ at 0.115. The replacement ratio is by consequence decreasing with the last wage (Table 3). Given these calibrations, the tax

Table 3: Replacement ratios according the social class

ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6	ϵ_7	ϵ_8	ϵ_9	ϵ_{10}
0.82	0.802	0.787	0.776	0.766	0.756	0.747	0.736	0.723	0.701

rate τ allowing to finance the pension is equal to 0.263.

3.2 The performances of the social security during the nineties

We now discuss of the model's implications concerning the distribution of earnings, wealth and income. The results show that the model is able to explain a large part of the inequalities observed in France.

3.3 The worker/retiree ratios

One way to deal with the distributional issue of pensions systems is to consider the relative situation of workers and retirees. The statistics reported in Table 4 correspond to earnings, (total) income, wealth and consumption ratios between workers and retirees in average. Like in the French data, the model implies that the gap between workers and retirees is smaller in terms of income than in terms of earnings (wages and pensions). This is the role of retirement savings. Nevertheless, the model underestimates the amount of wealth owned by the retirees. Concerning the repartition of the consumption, one can notice that the french social security program is able to reach the "consumption parity" between workers and retirees in average. This was the main objective of the program when the government implemented it at the end of World War II. The table 5 allows to verify that our model is able to generate a life cycle profile of income and wealth close to the data, whereas the earnings profile has been exogenously calibrated. However, the ratios at each age are slightly overestimated since the wealth of retirees is underestimated.

Table 4: Workers/retirees in average

	benchmark 1990	data
earnings	1.15	1.15
income	1.13	1.04
wealth	1.09	0.91
consumption	1.01	-

Table 5: The life-cycle profiles

		$C1/R$	$C2/R$	$C3/R$
earnings:	data	0.95	1.23	1.32
	model	0.95	1.23	1.32
income:	data	0.80	1.09	1.26
	model	0.93	1.24	1.34
wealth:	data	0.55	1.02	1.17
	model	0.80	1.22	1.45

These statistics are computed using the data reported in INSEE [1999b]. The reference year is 1996.

3.4 The inequalities in the nineties

Using the equilibrium stationary distribution of the asset λ and the decision rules, it is possible to compute the Gini indices of the earnings, the income and the wealth[5].

Table 6: Gini indexes

	Wealth	Income	Earnings
data	0.650	0.320	0.270
model	0.760	0.324	0.273

Source INSEE [1998] and INSEE [1999b].

The results reported in the table 6 show that the model over-estimates the wealth inequality measured by the Gini index. The generous social security system implies that the retirement motive provides a weak explanation of saving. This latter is mainly due to a precautionary motive against the labor risk: only high productivity ranked workers insure themselves and their progenies against a downward social mobility risk. Let us notice that altruistic behavior then explains a fraction of the large dispersion of wealth. This latter explains why the Gini coefficient is higher for income than for earnings. This matches the data particularly well.

4 New demographic regime and social security reforms

The preceding section has shown that the model is able to capture the main features of the inequality in the French economy. It gives some support for studying the implications of the new demographic regime expected in 2040. The predicted population aging implies that the ratio retirees/workers will be multiplied by approximatively 1.7. Faced this exogenous increase in the support ratio, reforms are unavoidable and they may differ in the degree of inequality implied.

In order to give an answer to these questions, we present the calibration of the new demographic regime and the possible adjustments of the social security program. We then present for each social security reform the inequality measures obtained at partial equilibrium (PE) and at general equilibrium

[5]Information on consumption inequality is unfortunately unavailable for the French economy.

(GE). In the first evaluation, we assume that the interest rate does not change between 1990 and 2040. In the second, we assume that the interest adjustments are complete.

4.1 The changes in economic environment

We keep all the parameters of the model constant. Only the transition matrix describing the population dynamics and the social security program are modified.

4.1.1 The demographic changes

Following the predicted evolution of the French population (see Charpin [1999]), we first assume that the annual growth rate of the population is zero from now on. Second, we assume that the increase of the number of retirees is explained by the increase in the life-time expectation. In 2040, the expected duration in retirement will be 30 years. We then decrease the probability of dying in the last period of retirement in order to match this duration, keeping unchanged the remaining probabilities. At the stationary equilibrium, the ratio between retirees and workers is then equal to 0.70, its predicted value in 2040 in France. All these demographic changes also modify the fertility rate which is now equal to 1.56, whereas the structural altruistic degree is obviously kept unchanged.

				$t+1$			
		$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
	$C1$	$1-\frac{1}{15}$	$\frac{1}{15}$	0	0	0	0
	$C2$	0	$1-\frac{1}{20}$	$\frac{1}{20}$	0	0	0
t	$C3$	0	0	$1-\frac{1}{5}$	$\frac{1}{5}$	0	0
	$C4$	0	0	0	$1-\frac{1}{4}$	$\frac{1}{4}$	0
	$C5$	$\frac{1}{11}\times\frac{1}{12}$	0	0	0	$1-\frac{1}{11}$	$\frac{1}{11}\times\frac{11}{12}$
	$C6$	$\frac{1}{14}$	0	0	0	0	$1-\frac{1}{14}$

4.1.2 The social security program reforms

In order to finance the increase in the support ratio, two strategies may be considered: first an increase in the taxes rate τ (program 2040-(I)), and second a decrease in the replacement ratio ρ (program 2040-(II)). Given the calibration of the new demographic regime these social security program adjustments are synthesized in table 7. The first strategy maintains the existing level of the inter-generational transfers toward the retirees providing by the social security, but uniformly increases the contribution of each worker.

Table 7: Social security program adjustments

	ρ	τ
1990	0.757	0.263
2040-(I)	0.757	0.375
2040-(II)	0.450	0.263

The second strategy consists in reducing the generosity of the PAYG pension system, leading to more individual savings.

Let us notice that the redistributive effect embodied in the social security arrangement[6] is *de facto* reduced when the replacement ratio is decreased.

4.2 Stationary equilibrium aggregates

Before studying the implication in terms of inequality, let us consider the first order moments of the equilibrium distribution for each demographic regime and each social security program (see table 8).

The interest is modified at general equilibrium. If the replacement ratio is hold constant, the interest rate is relatively high because the capital supply curve shift to the left is the weaker. This contrasts with the equilibrium where the tax rate is not modified: the agents save more in order to preserve their consumption when they will be retired. The decrease in the interest rate in all the scenarii implies via the factor price frontier relationship an increase in the aggregate wages.

Table 8: Social security reform and macroeconomic aggregates

	1990	2040-(I)		2040-(II)	
		PE	GE	PE	GE
A	2.44	6.2	2.59	8.21	2.81
A/Y	2.0	4.9	2.43	5.94	2.59
C	1.16	1.14	1.01	1.20	1.03
$E(U)$	-2.01	-2.06	-2.16	-1.99	-2.17
$a = 0$ (%)	29	14	35	7	27
r	5.75	5.75	5.09	5.75	4.44

For the same level of insurance provided in 2040 (scenario 2040-(I)), the increase in the expected life-time implies that the agents save more and

[6] Whatever the reform envisaged, $\tilde{\rho}$ is kept constant at its previous value of 0.115.

consequently are more able to protect them against the borrowing constraint. This implies a cost in term of consumption. The decrease in the replacement ratio enhances this phenomenon (scenario 2040-(II)). Nevertheless, the large increase in saving allows to enjoy more financial earnings and thus allows to preserve a high consumption.

4.3 The relative situation of workers and retirees

Table 9 shows that the ratio wages/pensions does not change in the new demographic regime if the replacement ratio is maintained. More generally, whatever the indicator considered, the relative situation of workers and retirees in average is not really affected by demographic changes.

Conversely, the decrease in the replacement ratio hugely increases the ratio wages/pensions. This effect on income is only partially compensated by wealth accumulation. At partial equilibrium, a large decrease in the replacement rate stimulates more intra-personal insurance and degrades the relative situation of retirees, despite the high level of interest rate. Indeed the inter-temporal transfers do not allow to preserve the consumption parity: the savings effort is not sufficient. This first result gives some arguments in favor of the current social security system: the agents have a preference for the present and hence they do not preserve themselves against poverty at the end of their life. At general equilibrium, these results are amplified by the decrease in the interest rate, implying that the consumption of the employees will be 37% larger than that of the retirees.

Table 9: Workers versus retirees

	1990	2040-(I)		2040-(II)	
		PE	GE	PE	GE
earnings	1.15	1.15	1.15	1.95	1.95
incomes	1.14	1.11	1.15	1.58	1.86
financial wealth	1.09	1.03	1.2	1.14	1.5
consumption	1.01	1.01	1.02	1.21	1.37
workers with $a = 0$ (%)	31	15	33	5	24
retirees with $a = 0$ (%)	26	12	37	8	31

PE : Partial Equilibrium with $r = r^*_{1990}$
GE : General Equilibrium with $r = r^*_{2040}$

These first results show that the decrease in the replacement ratio induces the larger inequality between workers and retirees. Nevertheless, beyond these statistics based on the means of the distributions, the theory is able to give some information about the intra-cohorts inequalities, and more generally about all the inequalities implied by the social security reforms.

4.4 The inequality of position in 2040

Inequality is measured by the inter-decile D9/D1 ratio and by the Gini index. They are computed on the stationary distribution. We call this cross-section approach of inequality "inequality of position". Notice that it corresponds to the empirical way the degree of inequality is usually measured. For comparing the different reforms, we only focus on the consumption inequality. We will mention wealth and income inequality only insofar as they allow to understand the former.

The new demographic regime and the different social security programs imply particular deformations of the wealth and consumption distributions. As the degree of inequality appears to be sensitive to the capital market equilibrium hypothesis (partial *versus* general equilibrium), we study both the effects before any price adjustments and after the equilibrium of the capital market.

At *partial equilibrium*, Table 10 shows that all social security reforms increase the degree of consumption inequality, even more in the 2040-(I) case. This result is quite surprising because the redistributive role played by the social security is larger with the reform keeping unchanged the replacement ratio, as opposed to the system where the replacement rate is decreased. Looking at the inter-deciles allows to go further. As can be seen from the the ratios D9/D1 and D5/D1 (see table 10), a lower replacement rate leads to a particular increase in the discrepancy between the agent at the bottom of the consumption distribution and those who are at the top of the distribution, but also at the median. Conversely, the situation of the middle class relative to the top of the distribution is better off in this case.

Considering now the general equilibrium outcome, the differences between the different reforms are reversed and magnified. The adjustment of factor prices provokes a more pronounced rise in inequality for the more funded system, whatever the criterion considered, whereas the degree of inequality is now unchanged for the case maintaining the replacement rate. Faced by the initial excess of capital supply, the decrease in the interest rate inducing higher earnings in average appears to play an opposite role on consumption inequality.

How can these results be explained more precisely? Investigating who are the losers in each social security programs may allow to shed light on the mechanisms at work. We present in table 11 the composition by age

Table 10: Inequality of position

		Gini	D9/D1	D5/D1	D9/D5
1990		0.27	4.76	1.53	3.09
2040-(I)	PE	0.29	5.37	1.81	2.97
	GE	0.27	4.23	1.42	2.98
2040-(II)	PE	0.28	5.9	2.12	2.76
	GE	0.29	5.87	1.96	2.98

of the lower decile of consumption[7]. Table 11 shows that the composition of the bottom of the consumption distribution is sensitive to the various social security reforms. In the benchmark scenario (the nineties), the young workers (age $C1$) and the old retirees (age $C5$ and $C6$) constitute the first consumption decile: this situation reproduces the life-cycle earnings profile in an economy where few agents hold financial assets.

Table 11: Decomposition of the first decile by age (in %)

		$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
1990		60.4	0	0	5.3	23.7	10.5
2040-(I)	PE	40.2	12.1	2.6	5	16.9	23.1
	GE	49.5	0	0	4.3	19	27.2
2040-(II)	PE	17.7	0	3.3	6.3	25.7	47
	GE	0	0	0.1	6	34.3	58.9

First, at *partial equilibrium*, it appears that the reform that keeps the replacement ratio unchanged (2040-(I)) leads some experienced ($C2$) and old workers ($C3$) to fall in the first consumption decile. The latter is then less determined by age and more by the social position in each cohort. In the nineties, 45% of the agents in the first consumption decile are at the bottom of the relative labor unit, whereas they are 54% in 2040-(I). This result

[7]The composition by age of the higher decile of consumption is reported in appendix B, table 14. Briefly speaking, this table shows that the composition of this decile is stable.

is explained by the impact of the liquidity constraint, which does not allow to smooth the increase of the tax for people who do not hold financial assets. This constraint is effective for the poorest agents who have not inherited. Hence, the heterogeneity in the leg distribution and the borrowing constraint explain why the increase of the proportional labor tax (2040-(I) PE) leads to degrade the relative situation of the poor and the middle class. Wealth heterogeneity and liquidity constraints magnify consumption inequality. It must be noticed that the pensions system that hold the replacement rate unchanged lead to the greatest wealth inequality (see the appendix A), consistently with the results obtained by Fuster [1999]: since bequests are concentrated among the upper wealth groups and the bequest motive is dominant relatively to the life-cycle motive, the distribution of assets become more concentrated. Indeed introducing more intra-personal insurance *via* a reduction of the replacement ratio implies all the agents save more. The risk associated to the retirement period is supported uniformly for all the workers and saving is the substitute to the large pensions.

This is not what happens when the replacement ratio is decreased: the first decile of consumption is mainly composed of retirees in this case, particularly the older ones. Here again, the substitution of individual savings to state pensions leads to sacrifice the retirees, victim of the lower generosity of the social security system. Discounting the future and the absence of actuarially-fair annuity contracts are at the core of this result. In this case, the social position is not the main explanation of the differences in consumption levels but it is still quite important: agents at the bottom of the productivity classes whatever their age represent 33% of the first decile of consumption. Indeed all the old retirees do not fall in the poverty trap. As the richest agents save in order to insure their progenies against the social mobility risk, this capital allows them to smooth their consumption when they overlive their expected time of death.

The price adjustment again exacerbates the effects obtained at partial equilibrium for the decreased replacement rate reform. The first decile of consumption is now entirely constituted by retirees. The decrease in the interest rate amplifies the lack of savings available in the retirement lifetime, especially for the retirees who live longer than they have expected. Conversely the effects described at the partial equilibrium for the reform increasing the tax rate (2040-(I) GE) again appears to be compensated by the prices adjustment. Firstly, the increase in earnings allows to absorb the higher labor tax: this phenomenon explains why the relatively low-ranking productivity workers are less numerous in the first decile of consumption for the reform characterized by a higher tax rate. The decrease in the interest rate affects some retirees negatively, in although a lesser extent than for the more funded case.

To sum up, it appears that each reform has its own drawbacks. Asset accumulation should be partly obligatory and based on actuarially-fair annuity contracts. PAYG system should introduce an age-dependent labor tax taking into account the efficiency rise during the working life-time. The relative importance of these shortcomings crucially depends of the adjustment of the interest rate. From this analysis based on inequality of consumption, it appears, taking into account all the price adjustments, that introducing more individual savings may lead to a lower performance. However, these measures catch the degree of inequality in consumption at a given year, the inequality of positions. The heterogeneity we have focused on may result from households intertemporal plans: this is clearly the case for the higher degree of inequality in consumption that we get in a more funded system. This however does not carry any information on the intertemporal welfare heterogeneity which may be considered as a more relevant measure of inequality.

4.5 The inequality of perspectives

In this last section, we analyze intertemporal welfare-based inequality measures, focusing now on what we call the inequality of perspectives. In which kind of economy is the expected welfare heterogeneity between the newborn agents the weakest? More generally, taking into account the whole age-cohorts, in which kind of economy is the inequality of perspectives the weakest?

4.5.1 Intertemporal welfare-based measures of inequality of perspectives

This section presents two measures used to evaluate the inequality of perspectives reached under various social security reforms. Both measures are based on the value functions underlying the household dynamic programs. We can easily recover the intertemporal values, averaged on assets, of the different classes of productivity ϵ_j (the representative agent of each productivity class) at each age C_i. We denote them $\mathcal{U}_{j,i}$:

$$\mathcal{U}_{j,i} = \sum_a \lambda(a, s = (\epsilon_j, C_i))v(a, s = (\epsilon_j, C_i)) \quad \text{for} \quad j = 1, ..., 10 \quad \text{and} \quad i = 1, ...6$$

One drawback of this welfare measure is that it can only rank different social security reforms. It would be useful to have a welfare measure that could be explicitly evaluated in terms of consumption. For this purpose, we compute the constant stream of consumption $\overline{c}_{j,i}$ leading to reach the level of intertemporal welfare $\mathcal{U}_{j,i}$. These permanent levels of consumption for each representative individual (j, i) can then be used to compute some kind of inter-deciles index.

We first address the expected welfare heterogeneity of new-born agents by comparing the constant streams of consumption of young agents ($C1$). We focus on the permanent consumption of the lowest productivity level representative agent relatively to the highest:

$$\Theta = \frac{\overline{c}(\varepsilon_{10}, C1)}{\overline{c}(\varepsilon_1, C1)}$$

In an overlapping-generation model, different age-cohorts of agents coexists. Hence, one may focus on the expected welfare heterogeneity between the better-off agent and the worse-off agent, whatever their age. This leads to study the following indicator:

$$\Delta = \frac{\max_{C_i}\{\overline{c}(\varepsilon_{10}, C_i)\}}{\min_{C_i}\{\overline{c}(\varepsilon_1, C_i)\}}$$

Hence this measure corresponds to the ratio between the higher permanent consumption level relatively to the lowest in the economy.

4.5.2 The inequality of perspectives across the new-born agents

The first line of Table 12 clearly shows that the inequality of perspectives at the beginning of life, Θ, is the lowest when the replacement rate decreases (2040-(II)). This result is true both at the partial and general equilibrium[8]. It remains to be explained why the inequality hierarchy between the different reforms is reversed when expected intertemporal welfare is considered.

The tax burden is weaker for workers in a more funded system. This relatively improves the situation of workers without financial assets, those born with the lower skills, by decreasing their probabilities to be constrained in the financial market. Smoothing their consumption is easier and thus welfare improving. Given the time-discount factor, these present gains are greater than the future expected losses associated with the period of retirement. At the opposite the increase in the tax rate (2040-(I)), allowing to finance more generous pensions, increase the intertemporal inequality. High tax rates increase the probability for new-born agents at the bottom of the earnings

[8]In this later case, all the measures are weaker as the financial assets held by the richest agents decrease, reducing the difference of expected intertemporal utility.

distribution to be constrained on the financial market: their relative welfare is lower. Hence, beyond the fact that the increase in tax constrains agents to save at the very beginning of their life, this policy can prevent agents from smoothing their consumption.

Adopting the inequality of new-born perspectives criterion then changes our vision of the social security reforms. It contrasts with the results based on the inequality of positions. This comes from the intertemporal dimension of this criterion, but also from the fact that the discount time factor gives more weight to the first periods of the life-cycle. This latter point introduces a bias in the evaluation of social security reforms, since a high replacement rate leads to involuntary savings at the first periods of life, while a more funded regime is problematic only in the old days. It can then legitimately be asked whether it is relevant to restrict our attention on the inequality of new-born perspectives.

Table 12: Inequality of perspectives

	1990	2040-(I)		2040-(II)	
		PE	GE	PE	GE
Θ	2.75	2.98	2.94	2.79	2.55
Δ	3.69	3.97	4.08	3.8	4.1

4.5.3 The inequality of perspectives across all the agents

We adopt in this section the approach corresponding to the measure Δ. It appears that the two reforms become very similar in their inequality of perspectives implications.

For the high ranking productivity worker, the risk is the downward social mobility. When they become retired, these agents are sure to keep their status. This explain why the retirees have the highest expected welfare in the nineties (see table 12). For a symmetric reason, the lowest welfare is reached by retirees at the bottom of the distribution of pensions. This is generally the case in all scenarii, except in the postponing retirement reform.

We have showed that a decrease in the replacement ratio (2040-(II)) disadvantages the old retirees who live longer than their expected life-time. An expected welfare-based criterion tends to minor the inequality implications of this risk. However, the inequality of perspectives increases relatively to the 1990 benchmark case, because the savings accumulated for a leg motive provide a by-product insurance for the richest agents. The effect of the general equilibrium magnifies this result because the decrease in the interest rate makes the leg motive even rarer among households. Nevertheless, the system where the replacement rate is maintained by an increase of the taxes is also responsible for a roughly equivalent increase in the inequality of perspectives (2040-(I)). Indeed the low-paid retirees know with a probability one that their children will be at the bottom of the earnings distribution: they will be constrained in the financial market and they will decrease their consumption due to the higher tax rate. The heterogeneity between legs thus explains the existing inequality.

5 Concluding remarks

A quantitative general equilibrium model in the lines of Castaneda, Diaz-Gimenez, and Rios-Rull [1998] has allowed us to shed light on the inequality implications of pensions reforms which will be undoubtedly necessary to cope with the ageing population in developed countries. We show that the very popular idea that a more funded system would ineluctably lead to more well-being inequalities can be justified by only focusing on inequality of positions in the case of a particularly low interest rate. This situation actually occur when general equilibrium is computed, due to the endogenous prices adjustment. This increase of the retirement insurance premia indeed degrades the relative consumption level of retirees who overlive their expected time of death. However, our quantitative exercise reveals that reform that would hold the generosity of the pay-as-go system unchanged, by increasing the tax rate on labor, also imply some unwilling consequences for inequality which are generally underestimated. They are related to the heterogeneous way, due to the wealth inequality and the existing liquidity constraints, by which agents cope with the increased tax. They lead to degrade the relative situation of the lower productive workers. If they are not strong enough to dominate the inequality of positions induced by a decreasing replacement rate pensions reform, they lead to reversed results when the inequality of perspectives of the new-born agents is retained. Considering the inequality of perspectives of all the agents indicates that the two reforms lead to a similar level. It appears that the leg and precautionary savings motives play a crucial role in the explanation of these results.

All these results reveal that the inequality ranking of different social security reforms heavily depends on the way inequality is defined. It must also be noticed that only consumption enters in these different measures of inequality since this is the only variable valued by households. Taking into account both leisure decisions could allow to go further in the analysis of the inequality implications of pensions reforms. For instance, some degree of heterogeneity in the disutility of working could lead to introduce some supplementary sources of welfare inequality, especially when delaying the retirement age is considered. This is left for further research.

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Appendix

A Inequality of wealth

Table 13: Wealth heterogeneity measures (Gini indexes)

1990	2040-(I)		2040-(II)	
	PE	GE	PE	GE
0.77	0.65	0.78	0.54	0.72

B Composition by age of the higher consumption decile

Table 14: Consumption – composition of the top decile by age (in %)

		$C1$	$C2$	$C3$	$C4$	$C5$	$C6$
1990		15.6	37.6	10.5	8.1	20.6	7.6
2040-(I)	PE	14.5	30.9	8.9	7.2	18.5	20
	GE	12.5	33	9.2	7.1	18.2	20
2040-(II)	PE	16.6	41.1	10	6.2	13.8	12.3
	GE	21.2	40.6	9.7	6.7	13	8.8