Distributional effects of social security reforms: The case of France

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Abstract. This paper assesses the impact of two social security reforms using a calibrated, dynamic life cycle model. It quantifies the long-run distributional impact of two sets of reforms in France: (1) the 2013 reform of Prime Minister Ayrault, which modified the parameters of a defined benefit (DB) plan, and (2) a hypothetical reform that changes the system to a notional defined contribution (NDC) plan, similar to that in Italy. First, on aggregate welfare, the Ayrault reform and the hypothetical switch to NDC yield contrasting results. The Ayrault reform improves aggregate welfare, which is not the case for the NDC reform. Welfare comparisons are made with respect to the “benchmark economy,” where increases in life expectancy occur and are dealt with only through a higher contribution rate. Second, both reforms yield unequal distributions of welfare changes, with low-skill workers on the losing end. Under the Ayrault reform, low-skill workers delay retirement by two years, to age 62. Under NDC reform, pensions for low-skill workers fall substantially as inequalities during the work life translate directly into inequalities in pensions. The switch to an NDC scheme leads to a more unequal society in terms of asset and welfare distribution.

Résumé. Les effets redistributifs des réformes de retraite: le cas de la France. Cet article utilise un modèle de cycle de vie dynamique calibré pour quantifier l’impact distributif à long terme de deux réformes du système de retraite en France: (1) la réforme Ayrault de 2013, qui modifie les paramètres d’un système à prestations déterminées (PD); (2) un passage hypothétique à un système de comptes notionnels à cotisation déterminé (NDC), comme en Italie. Tout d’abord, les deux réformes donnent lieu à des résultats opposés en terme de bien-être aggrégé. La réforme Ayrault améliore le bien-être total, ce qui n’est pas de la réforme NDC. Les comparaisons de bien-être sont effectuées par rapport à une économie de référence caractérisée par une hausse de l’espérance de vie et des taux de cotisation. De plus, les réformes donnent lieu à des distributions inégales du bien-être, avec les travailleurs peu qualifiés dans la queue de distribution. En effet, la réforme Ayrault les contraint à travailler deux années supplémentaires, jusqu’à l’âge de 62 ans. Le système NDC conduit à une réduction marquée des pensions de retraite, en

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particulier pour les travailleurs peu qualifiés, les inégalités au cours de la vie active se répercutant sur le montant des pensions. Le passage au système NDC se traduirait par une hausse des inégalités de patrimoine financier et de bien-être.

JEL classification: E24, H31, H55, J26

1. Introduction

The social security (SS) systems of many Western nations have been facing a solvency challenge because of aging populations. As a result, most OECD countries implemented reforms over the past two decades to sustain their pay-as-you-go (PAYG) pension systems, which had been jeopardized by this demographic trend. However, reforms are always problematic because benefits are based on individual work intensity, hence creating benefit inequality among recipients. They also affect earnings and savings as well as the labour supply, hence redistributing benefits within and across generations. Political support, either for or against reform, is often rooted in equality or equity issues in this redistribution. It is therefore crucial for Western nations to be able to quantify the distributional effects of their SS reforms in terms of who benefits and who loses, and by how much.

This paper investigates how different national SS reforms designed to offset the impact of aging populations have affected, or could affect, the distribution of wealth among workers. Some countries, like France, have manipulated the parameters of their defined benefit (DB) pension plans, which provide predetermined benefits based on length of service and salary earned. Other countries, such as Italy and Sweden, have taken a drastic approach by switching from DB plans to notional defined contribution (NDC) systems, in which a worker’s pension depends on contributions and investment returns. Our approach to assessing the long-term distributional effects of SS reforms across different skill groups is original because we evaluate the consequences of two sets of reforms to France’s pension system. First, we discuss the real reform—i.e., that actually implemented in 2013 under the auspices of Prime Minister Jean-Marc Ayrault and based on a DB pension plan—and evaluate its redistributive effects in steady state after carefully mapping it into our model. Second, we posit hypothetical reforms to the French SS system based on an NDC system similar to that implemented in Italy with the 1990s reform. Both

1 NDC systems mimic the characteristics of the defined contribution systems in the way that risk is shared, but they are not fully funded and are in fact similar to PAYG systems (see Auerbach and Lee 2009 and Barr and Diamond 2006 for details).

2 Emmanuel Macron, the French president, also plans to reform the French pension system by moving to a Swedish-type NDC system. See lesechos.fr/elections/dossiers/03037337991/03037337991-macron-six-reformes-sociales-en-18-mois-2092790.php.
the real and hypothetical reforms aim to increase labour supply by introducing strong incentives for workers to postpone retirement, but the implications for individuals differ depending on their type of work. We then use a model of endogenous retirement and wealth that captures possible changes to retirement age in an economy where the population is heterogeneous and comprises individuals with different skill levels (low, middle, high), ages, employment status and asset holdings.

This paper draws on a large literature, focused primarily on the United States, that uses a life cycle framework for the analysis of SS policy reforms (DeNardi et al. 1999, Conesa and Krueger 1999, Huggett and Ventura 1999, among others). Literature on the French system is almost non-existent, with the exception of Hénin and Weitzenblum (2005), who investigate the welfare consequences of the 1990 reforms; obviously this analysis does not consider the 2013 reforms. In accordance with Rust and Phelan (1997), Huggett and Ventura (1999), Fuster et al. (2003) and Hairault et al. (2008), we use a dynamic life cycle model in which the individuals are heterogeneous with respect to age, wealth and employment status. In particular, we build on the model by Hairault et al. (2008).

The paper presents two significant results based on comparisons made with respect to a reference economy in which a higher contribution rate alone is used to absorb the SS deficit generated by an increase in life expectancy. First, on aggregate welfare, the Ayrault reform and the hypothetical switch to NDC yield contrasting results. The Ayrault reform improves aggregate welfare, which is not the case for the NDC reform. With respect to this reference economy, the Ayrault reform combines a delayed legal retirement age and a smaller increase in the contribution rate. This combination is preferred by all individuals to a larger increase in the contribution rate without reform. In contrast, the hypothetical switch to NDC yields negative aggregate consequences, with individuals requiring a 6.45% increase in income on average to support the reform. This is due to the drastic fall in replacement ratios.

Second, both reforms yield unequal distributions of welfare changes, with low-skill workers on the losing end. Under the Ayrault reform, low-skill workers delay retirement by two years, to age 62. Under NDC reform, pensions for low-skill workers fall substantially as inequalities during the work life translate directly into inequalities in pensions. With a change to NDC, pensions would fall drastically and individuals would be compelled to save more. However, since low-skill workers do not save as much as middle- or high-skill workers, the switch to an NDC scheme leads to a more unequal society in terms of asset and welfare distribution.

The paper is organized into four sections beyond the introduction. Section 2 describes the French pension system and the model. In section 3, we calibrate the model and check its fit with the data. Section 4 provides a comparison of the long-term distributional effects of SS reforms within and across skill groups. We conclude in section 5.
2. Description of the economy

2.1. The French pension system

The French pension system discussed in this paper covers only private sector workers, who make up approximately 70% of the national labour force. For the purposes of modelling, we do not include self-employed individuals and civil servants, who represent 10% and 20% of the labour force, respectively.3

2.1.1. The two-pillar system

This French pension system is an insurance system with two pillars. The first is the régime général (general regime), a DB pension plan run by the national government through an agency, the Caisse nationale d’assurance vieillesse (Cnav). The government can change the pension formula at this level only. The second pillar consists of the mandatory complementary schemes (MCSs): Agirc and Arrco, which are NDC pension plans run by private sector unions and employers (see figure 1). During the 2013 Ayrault reforms, policy debates focused on how the pattern of Cnav benefits could be modified in order to encourage people to postpone retirement, leaving MCSs to allow for changes in normal retirement age in their pension formula, in particular the decrease in pension benefits in cases of retirement before the full pension age.

Both Agirc and Arrco are PAYG systems4 but rely on different pension formulas and have separate budgets. Thus, for the purposes of this paper, we compute three contribution rates separately, one for each segment of the French pension system: Cnav, Arrco and Agirc. In addition, since the MCSs provide 40% of retirement pensions for wage earners in the private sector (Blanchet and Pelé 1999), it would logically appear that alterations to the general regime would affect only 60% of a worker’s total pension. In order to gauge the empirical relevance of such a claim, and capture the effects

3 In order to preserve the tractability of the model, we disregard French self-employed individuals and civil servants, who are characterized by different pension regimes. The earnings process of the self-employed worker displays more dispersion and a lower mean than for salary/waged workers (Hamilton 2000). Civil servants do not face any employment risk. In addition, labour market status would have required a more complex modelling, especially for self-employment. Indeed, as suggested by the literature on self-employment (Blau 1987), self-employed workers actually change occupation to/from wage employment during their career.

4 MCSs pay benefits directly out of current contributions. Workers continue to pay for today’s pensioners, but their contributions are also credited to notional accounts, which have a fixed rate of return. When they retire, their pension benefits are based on the notional capital they have accumulated, which is turned into annuities through a formula based on life expectancy at their retirement age.
FIGURE 1 The French private sector pension system

of pension reforms, we carefully map the two-pillar system onto the model. Pension formulas for these two pillars are reported in online appendix A.

In all pension schemes, the social security ceiling plays a key role in the pension computation. First, in the Cnav pension formula, only wages below the cap are taken into account in the computation of the average wage. Second, MCSs apply different contribution-rate values during a worker’s career and upon retirement for wages below and above the cap. These elements introduce distributive effects in the computation of the pension formula. This point will be developed in section 4.

2.1.2. Two pension reforms
As noted above, we evaluate the economic performance of the French pension system under two types of reform: the real reform introduced by Ayrault in 2013 and a hypothetical NDC reform based on that enacted in Italy.

Ayrault (2013)
This real reform altered the Cnav pension formula to induce significant retirement delays in the following five ways: (i) the early retirement age is now 62, rather than 60, (ii) retirees are eligible for a full pension at age 67 or between ages 62 and 67 if they contributed to their pension plan for at least 43 years, (iii) for people between ages 62 and 67, retirement is still possible but with a downward adjustment of benefits, (iv) the penalty for early retirement is now reduced and (v) working beyond the required 43 years of contribution
is rewarded; a bonus is given only to employed workers, not to those who are unemployed or inactive.

NDC reform

The hypothetical reform poses the question: What would happen if France had implemented a similar reform as the 1995 Italian reform instead of the Ayrault reform? To answer this question, we posit an early retirement age of 60 in the model. In addition, as suggested by Bozio and Piketty (2008), we replace the current two-pillar system (general regime and MCSs) with a single system based on notional accounts only, not unlike the contributive schemes in the MCSs. Under this regime, workers contribute a fraction of their earnings annually to the pension plan. Each contribution is capitalized at an annual fixed rate of 1.2%. The sum of capitalized contributions is turned into annuities using coefficients of adjustments. These coefficients are taken from the Italian laws, as reported in OECD (2013). We map the exact pension formula into the model (see online appendix A3).

2.2. A life cycle heterogeneous-agent model with endogenous retirement

Overview of the model

In this paper, we use a life cycle heterogeneous-agent model with endogenous retirement and savings, assuming that labour market status consists of employment, non-employment and retirement. Transitions between employment and non-employment are stochastic. Workers cannot be insured completely against the idiosyncratic risk of being non-employed. Beyond the heterogeneity arising from uninsurable shocks to individual employment opportunities, we also take into account life cycle features. First, within each time period, some individuals are born and others die. Thus we take into account different age groups and consider stochastic aging along the lines of Castañeda et al. (2003). Second, individuals face borrowing constraints and cannot hold negative net assets at any time. We introduce wealth accumulation along the same lines as Rust and Phelan (1997) and Hairault et al. (2008). Third, the interest rate is endogenously determined to equalize the supply and demand of financial assets. Fourth, we assume that agents are altruistic with respect to future generations, i.e., they have a bequest motive. In these ways, we ensure that the model does not allow for aggregate uncertainty. Another important feature of the model is the skill structure. We distinguish several skill categories, each with its own mortality risk, employment transitions, lifetime earnings and age at the end of education. Hence the model will be able to predict savings and retirement decisions within and across these categories by allowing each group to differ substantially in the incentives its members face. Retirement behaviour is endogenous. In order to analyze retirement

5 We focus on the risks that matter for pensions. In doing so, we follow Fuster (1999) and Fuster et al. (2003), who argue that incorporating altruism,
decisions, we take into account two key features of the retirement process. First, pensions depend on lifetime earnings, which are mechanically linked to non-employment spells during the work life. Second, the employment rate drops drastically as workers reach older ages. We capture the change from employment to non-employment while taking into account the fact that the low labour demand for older workers is necessary to measure the implications of any policy aiming at delaying retirement (Hurd 1996). Contribution rates will endogenously adjust to balance PAYG pension plans.

A stationary problem
In order to define the stationary equilibrium, we divide all variables by the growth rate of technological progress \((1 + \gamma)\). We denote stationary consumption, \(c\), and wealth, \(a\), by \(c = C_t/(1 + \gamma)^t\) and \(a = A_t/(1 + \gamma)^t\), whereas the wage, \(w\), and the pension, \(\omega\), are denoted in stationary terms by \(w = W_t/(1 + \gamma)^t\), \(\omega = \Omega_t/(1 + \gamma)^t\).

2.2.1. Individual risks and life cycle
The model distinguishes three ability groups: high, middle and low (denoted \(H\), \(M\) and \(L\), respectively). Using these ability groups, the model includes three exogenous stochastic shocks that affect individuals: social mobility via intergenerational skill changes, aging and non-employment risks.

Social mobility
The first exogenous stochastic shock is social mobility via intergenerational skill changes. Skill level is determined at birth by a random draw. An individual’s skill status is not modified in their lifetime. The ability at birth follows a Markov matrix \(\Phi(i’|i)\); a newly born individual’s skill status \(i’\) is affected by their father’s \(i\) (Fuster et al. 2003).

Life cycle
An individual’s life is divided into two stages: (i) a typical life cycle wage profile and (ii) the time of retirement decisions. The first stage involves three age groups: the young group (denoted \(Y\), this period captures the years after first entry on the labour market), the adult group (denoted \(A\), this period captures the wage increases during the work life) and the old group (\(O\), this period captures the end of the work life). The calibrated wage profile will depend on the age group. As a worker gains job experience during their life cycle, we assume that the productivity of the labour input, hence wage, grows with worker’s age, which is consistent with the French data. Following Castañeda et al. (2003), agents age stochastically and sequentially during this mortality risk and ability shocks is very important in order to obtain differences in induced preferences over the desirability of SS reforms. We take into account these dimensions in our model. In their models, as in ours, an individual receives at birth the realization of a random ability that determines his lifetime labour ability.
first stage of the work life. Individuals face a given probability to move to the next age group. The probability of remaining a young (adult) worker during the next period is $\pi_Y (\pi_A)$. The second stage of the individual work-life cycle is when the worker faces retirement decisions. For the purposes of the model, the early retirement age (ERA) is when individuals can start claiming pension benefits. From the ERA onwards, individuals face a probability of dying that is specific to their labour ability. Also, after an individual dies, he is followed by only one child, thus ensuring that individuals belonging to the same family line do not overlap. In the model, the time of retirement decisions is one year prior to the ERA. If the agent is alive at age ERA-1, he chooses either to retire the next year (at age ERA) or remain in the labour market, whether employed or not. All agents who have not retired by age 69 retire at age 70. The modelling of this second stage of the life cycle allows us to compute the percentage of individuals who choose retirement for each age from ERA to age 69. This age structure reconciles two requirements: it provides a parsimonious modelling of the work life, i.e., to reduce the computational burden, while allowing for a detailed analysis of retirement decisions.

**Non-employment risk**

The third exogenous stochastic shock in the model is the non-employment risk that plays a role in retirement decisions; thus we do not account for the unemployment risks of both younger workers and those in the adult stage.

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6 Figure B1 in the online appendix summarizes the life cycle features. In this first stage of life, we do not assume deterministic aging. Indeed, stochastic aging reduces the computational burden while allowing us to capture the wage profile along the work life.

7 The early retirement age is specific to each reform. In the case of the Ayrault reform, older workers are 55–61 years old, instead of 55–59 in the other scenarios. Also note that workers differ in terms of age at end of education according to their ability. They therefore do not experience the same number of working years before ERA. This translates into different probabilities $\pi_Y$ across ability. The calibration in table 2 is set accordingly.

8 In the first stage of life, we ignore death probabilities as in Castañeda et al.’s (2003) model. We want a streamlined model in order to capture the key ingredients for retirement choices. In spite of this simplification, the model fit in terms of retirement choices and financial strain on the PAYG system is satisfactory (section 3.4).

9 In all scenarios, the population growth is constant. This assumption is consistent with the recommendations by Aglietta et al. (2002) when assessing future French demographic trends.

10 Even though the unemployment rate is high in France, unemployment risk at younger ages does not affect retirement decisions at older ages (Blanchet et al. 2007).
of their work life.\textsuperscript{11} Introducing the idiosyncratic risk of being unemployed, \( U \), from ages 55 to 59 is essential to the understanding of retirement decisions and the implications of any policy designed to delay retirement age. We also take into account the special programs for older, non-employed workers, i.e., \textit{cessation d’activité anticipée}, or early withdrawal from the labour market that allow them to remain non-employed before the ERA (see a description of these programs in Blanchet et al. 2007). Older workers in these programs have a third labour market status, denoted as “P” in the model.

Thus we assume that older individuals face a non-employment shock when aged 55 to 59, with \( \xi = E, U, P \). Employment transitions \( P(\xi'|\xi) \) follow a Markov process. When non-employed \( (\xi = U, P) \), workers receive a non-employment benefit, either from unemployment or early withdrawal, until the age of full pension rate. Consistent with empirical evidence, we consider that the non-employment states \( (\xi = U, P) \) are absorbing states until retirement. Once in these programs, unemployment or early withdrawal, older individuals do not go back to work; rather, they choose to retire as employed or non-employed. As their pension depends on their work history, \( \xi \) is still a state variable for retirees. As a result, for each retirement age, we have individuals who have retired from work, \( \xi = RE \), are in a state of unemployment, \( \xi = RU \), or participate in specific older workers’ programs, \( \xi = RP \). Therefore, an individual has four state variables: \( a \), the beginning-of-period financial wealth; age \( (k = Y, A, O, ERA, ERA - 1, ERA + 1, \ldots, 70+) \); skill level \( (i = L, M, H) \); and employment status \( (\xi = E, U, P, RE, RU, RP) \).\textsuperscript{12}

\textbf{2.2.2. Firm and technology}

The production technology of the representative firm is given by a standard constant return to scale Cobb–Douglas function, where \( \alpha \in (0, 1) \) is the labour’s share of output, \( K \) and \( L \) are aggregate capital and the weighted average of efficient hours worked, respectively, and \( A > 0 \) is total factor

\textsuperscript{11} This choice is driven by the French data summarized in Blanchet et al. (2007), who show that the exit rate from employment is very low for prime-age workers in France, much lower than in the United States. Blanchet et al. (2007) point out that the striking feature of the French labour market is the fall in the employment rate of workers aged 55–59. In addition, while the probability of returning to employment from non-employment is still slightly positive at age 50, it becomes zero past ages 56 or 57. This very low rate of return to employment sharply contrasts with the United State situation where rates of return to employment, though they also decline after 50, remain much larger than in France. Workers aged 55+ have access to specific arrangements of unemployment insurance (including an exemption from seeking employment) until retirement.

\textsuperscript{12} More details are in online appendix B. In particular, table B1 summarizes the employment status as a function of age, figure B2 presents the labour market transitions in the model and appendix B3 provides more detail about the non-employment risk.
productivity. We assume that $A$ grows at an exogenous and constant rate and that the aggregate capital stock $K$ depreciates at rate $\delta$. The profit maximization behaviour of the firm gives rise to first-order conditions that determine the net real return to capital,

$$r = (1 - \alpha) A \left( \frac{L}{K} \right)^{\alpha} - \delta$$

(1)

$$\bar{w} w_i^k (1 + \Theta_f(\bar{w} w_i^k)) = \mu_i^k A \left( \frac{L}{K} \right)^{\alpha - 1},$$

(2)

where $\Theta_f(\bar{w} w_i^k)$ is the contribution paid by the firm for the general regime and MCSs ($\Theta_f(\bar{w} w_i^k) = \tau_{cnav}, \tau_{arrco}, \tau_{agirc}$) for worker of age $k$ and skill level $i$. The contributions adjust endogenously to balance the social security budget. As can be seen from equation (2), the wage bill is determined by two elements: a real wage rate per effective labour ($\bar{w}$) and worker’s wage ($w_i^k$). Workers’ wages are calibrated and differ across skill groups $i$ and age groups $k$. Workers’ productivity also differ across skill groups $i$ and age groups $k$; this is captured by $\mu_i^k$. $\bar{w}$ is endogenously determined because of the endogenous value of the interest rate. After determining the equilibrium $r$ on the financial market, we use equations (1) and (2) to determine $\bar{w}$. See online appendix C for more details.

2.2.3. Household preferences, budget restraints and optimization

Household preferences

Individuals derive utility from leisure and consumption as well as from the consumption of their offspring. As in Huggett and Ventura (1999), we assume that the instantaneous utility function, $u$, is a constant relative risk aversion (CRRA) in which the period utility function is strictly concave,

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

where $\tilde{\sigma}$ is the risk aversion and $\eta$ the weight of leisure $(1-l)$ in the instantaneous utility. Labour is inelastically supplied by individuals as in Fuster et al. (2003). When employed, workers supply $\bar{l}$ hours worked. When non-employed (unemployed, in early withdrawal or retired), $l = 0$. Labour participation is endogenous at older ages as individuals choose whether to retire or not. Indeed, as we focus on policy reforms aiming at delaying retirement, the age of retirement is the core issue in the policy reforms we investigate. Time endowment is normalized to 1.

The utility function is Cobb–Douglas, in which consumption, $c$, and leisure, $l$, are positive.\(^\text{13}\) The model has altruistic preferences as in Fuster et al. (2003). Individuals derive utility from their own lifetime consumption and from the

\(^{13}\) The reasons for this choice are that this function is compatible with a balanced growth path and the parameters needed for the calibration have been
happiness of their offspring. \( \varrho \) is the degree of altruism. The parameter \( \varrho > 0 \) captures in a simple way the individual’s concern for the welfare of her offspring.

**Household’s budget constraint**

Individuals are limited as follows:

\[
(1 + \gamma) a' = (1 + r)a + y(k, i, \xi) - c \\
a' \geq 0, 
\]

where \( a' \) is the next period’s asset level and \( (1 + \gamma) \) is the growth rate of technological progress. Individuals face two sources of capital market inefficiency. The first source stems from market incompleteness that prevents them from insuring completely against idiosyncratic risks. The second source comes from a borrowing constraint: net asset holdings cannot be negative \( (a' \geq 0).^{14} \)

\( y(k, i, \xi) \) denotes the labour income net of the contributive tax.

\[
y(k, i, \xi) = \begin{cases} 
\bar{w}w^k_i - \Theta(\bar{w}w^k_i) & \text{if employed } \xi = E \text{ and } k = Y, A, \ldots, 69 \\
[\bar{w}w^k_i - \Theta(\bar{w}w^k_i)]\theta^{k,\xi}_i & \text{if not employed } \xi = U, P \text{ and } k = O, ERA - 1, \ldots, 69 \\
\omega^{k,\xi}_i & \text{if retired } \xi = RE, RU, RP \text{ and } k = ERA, \ldots, 70+
\end{cases}
\]

When employed, a worker has labour income of \( \bar{w}w^k_i \) net of \( \Theta(\bar{w}w^k_i) \) contributive taxes (that are functions of contributive rates \( \tau_{cnav}, \tau_{arrco}, \tau_{agirc} \)). Only the share of contributive taxes paid by employees is introduced in the individual’s budget constraint. If non-employed, a fraction of wages is paid as non-employment benefits. \( \theta^{k,\xi}_i \) denotes the replacement ratio associated with non-employment benefits (\( \theta^{k,U}_i \) refers to unemployment benefits, \( \theta^{k,P}_i \) refers to benefits for early withdrawals) at age \( k \) and skill level \( i \). \( \omega^{k,\xi}_i, \xi = RE, RU, RP \) denotes the pension of an individual who retires at age \( k \) and skill level \( i \).

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14 This assumption precludes the possibility of borrowing. We choose this assumption of tight financial constraint for the sake of simplicity. Indeed, when individuals are allowed to borrow, we need to determine the appropriate borrowing limit. In order to ensure that households are able to reimburse their loan, this maximum amount of borrowed money undoubtedly depends on future income flows and value of current assets. Aiyagari (1994) proposes a borrowing limit set at the worst possible outcomes in terms of income flows. For example, in models of financial accelerator or entrepreneurship, the borrowing limit is an endogenous fraction of assets. The question of the endogeneity of the borrowing limit and how it relates to retirement decisions is left for future research. In addition, this restrictive hypothesis of very tight financial constraint still allows the model to replicate the wealth distribution observed in the data, especially at the bottom of the distribution. See table 7, section 3.4.
after being previously $E$ (employed) or non-employed (whether $U$ or $P$). In the model, pension benefits $\omega_{i}^{k\xi}$ are computed with French SS formulas and an NDC system as described in section 2.1 and in online appendix A.

Optimization problem in the first stage of the life cycle $k = Y, A, O$: the optimal asset accumulation in a life cycle setting

The discount rate is set in order to be compatible with the utility choice, that is, $\tilde{\beta} = \beta (1 - \eta)(1 - \sigma)$. Individuals maximize their optimal consumption path. Below are the value functions subject to equations (3) and (4). The value function of workers at age $k = Y, A$ is

$$V(a, k, i, E) = \max_{c \geq 0, a'} u(c, l) + \tilde{\beta} \left[ \pi_k V(a', k, i, E) + (1 - \pi_k) V(a', k + 1, i, E) \right]$$

At age $k = O$, individuals face a non-employment risk. For $k = O$ and $\xi = E$

$$V(a, O, i, E) = \max_{c \geq 0, a'} u(c, l) + \tilde{\beta} \left[ \pi_O V(a', k, i, E) + (1 - \pi_O) P(\xi' | \xi) V(a', ERA - 1, i, \xi') \right]$$

For $k = O$ and $\xi = U, P$

$$V(a, O, i, \xi) = \max_{c \geq 0, a'} u(c, l) + \tilde{\beta} [\pi_O V(a', ERA - 1, i, \xi) + (1 - \pi_O) V(a', ERA - 1, i, \xi)].$$

Optimization problem in the second stage of the life cycle: Mortality risk, intergenerational skill change, retirement and saving decisions

From the age of ERA-1 onwards, individuals face mortality risk. For ages $k = \{ERA - 1, ERA, ..., 68\}$, individuals make savings and retirement choices. From the age of ERA-1 onwards, individuals have the legal right to claim a pension the following year. We will adjust ERA depending on the reform or scenario analyzed. Each individual compares the future value of being retired next year to the future value of remaining on the labour market next year, given the probability of death $\pi_k^i$.

Individuals observe their employment status as $\xi = E$ (employed), $U$ (unemployed) or $P$ (early withdrawal). As current income, pension benefits and labour market shocks depend on the current labour market status prior to retirement, value function is different for an individual with a different labour market status. We report below the choice faced by employed workers $\xi = E$ of age $k$ and skill $i$. Value function maximization is subject to equations (3) and (4).

$$V(a, k, i, E) = \max_{c \geq 0, a'} u(c, l) + \tilde{\beta} \left[ \pi_k^i \Phi(i' | i) gV(a', Y, i', E) + (1 - \pi_k^i) Max (V(a', k + 1, i, E), V(a', k + 1, i, RE)) \right]$$

15 As shown in figure B1 in the online appendix.
16 Institutional details in table A1 in the online appendix.
Let us denote $\Psi(a, k, i, \xi)$ as the optimal retirement choice for $k = \text{ERA}, \ldots, 68$:

$$
\Psi(a, k, i, \xi) = \begin{cases} 
1 & \text{if } V(a, k, i, \xi) \geq V(a, k, i, \xi') \\
0 & \text{otherwise,}
\end{cases}
$$

(5)

where $\xi = E, U, P$ and $\xi' = RE, RU, RP$. For ages $k$, without retirement choices, we define $\Psi(a, k, i, E) = 1$ for employed individuals and, for non-employed, $\Psi(a, k, i, U) = 0$, $\Psi(a, k, i, P) = 0$. $\Psi(a, k, i, \xi)$ will be useful to compute the aggregate labour supply (see online appendix C).

Individuals can die with probability $\pi^i_k$, in which case a new young individual is born with a skill group which is determined by the mobility matrix $\Phi(i'|i)$. Following Castañeda et al. (2003), at the beginning of the first period of life, the young individual inherits the estate of his deceased father. Conditional on being alive (with probability $1 - \pi^i_k$), workers age by one year (hence the $k+1$ in the future state) and choose whether to retire or not. Retirement choice is captured by the max operand in the future values of employed $V(a', k+1, i, E)$ and retired individuals $V(a', k+1, i, RE)$. In the model, once individuals are retired, they remain retired, which is consistent with French data.

**Household optimization for individuals in the oldest age category, $k = \{69, 70+\}$**.

Individuals optimize only their consumption and savings. Their optimal choice is on $a'$ and $c$, given their death probability. At age 69, individuals can retire only in the age group 70+. They do not make any retirement choice. Their future value function is only retirement. The future of retirees of age 70+ is to remain in their current state if they survive or give birth to a single child if they die. The rest of the value functions maximizations are in online appendix B4.

Given the SS system, a stationary equilibrium\(^\text{17}\) comprises individuals’ choices for consumption, savings and retirement: $c(a, k, i, \xi), a'(a, k, i, \xi), \Psi(a, k, i, \xi)$; value functions $V(a, k, i, \xi)$; a stationary distribution of individuals $\lambda(a, k, i, \xi)$; prices of labour and capital $\bar{w}, r$ and $\Theta_f(\bar{w})$; and a set of contributive taxes of retirement schemes $\tau_{\text{cnav}}, \tau_{\text{arrco}}, \tau_{\text{agirc}}$. We define the equilibrium in online appendix C. We implement numerical techniques based on a discretization of state variables and value function iteration (Ljungqvist and Sargent 2000).

\(^\text{17}\) For computational reasons, we are discarding transitional dynamics as in Huggett and Ventura (1999) and Fuster et al. (2003). We have 213 agent types with different ages, ability levels and labour statuses and endogenous retirement. We focus on the impact of reforms after the transition is over, which allows us to identify long-term welfare consequences of the reforms. The investigation of transitional dynamics is interesting but left for future research.
3. Calibration and model fit

The model period is a year. In order to check the empirical relevance of our model, we compare its predictions with the French data prior to both the increase in retirement ages and pension reforms. As a result, our benchmark calibration relies on data from the 1990s. The calibration focuses on male private sector workers.\(^{18}\) Our aim is not to reproduce exact population patterns but simply to adjust to the stylized facts of the French economy.

3.1. Individual uncertainty

3.1.1. Skills

We use occupations to create “skill” groups and provide three broad categories: low-skill (L) workers, middle-skill (M) workers and high-skill (H) workers.\(^ {19} \) Skill levels are defined by the French bureau of statistics (Insee). Low-skill workers are unskilled workers and clerks dealing with non-specialized office work in administrations or firms, middle-skill workers are white-collar workers and high-skill workers are highly skilled workers and executives. We use data on male private workers.

We can compute the stationary distribution of skills from the social transition matrix (see table 1),\(^ {20} \) i.e., 55.9% of individuals in the economy are L-workers, 25.79% are M-workers and 18.31% are H-workers. This is consistent with the aggregate skill distribution from the French labour force survey (LFS) in the 1990s.

3.1.2. Demographics

In the first stage of the life cycle

We study three stages of work life: youth, adult and old. With regards to the first stage of the life cycle, we assume that individuals are born as young

\(^{18}\) Adding women would have required a complex modelling because of several female-specific elements in retirement decisions, such as endogenous fertility and the way child rearing should be taken into account in the pension formula. Women are characterized by a lower wage profile over the life cycle and higher non-employment rates than their male counterparts. The model could thus be interpreted as an optimistic scenario in an economy where everybody behaves like men in terms of labour decisions. We show that, even in this optimistic scenario, the hypothetical NDC reform leads to significant welfare losses.

\(^{19}\) The correlation between the parents’ human capital and that of their offspring is given by the social mobility matrix \( \Phi \) computed from the 1993 enquête sur l’Emploi (labour force survey); see table 1. The probability for an H-worker to have a child who belongs to a lower ability class is more than 50%. This will provide a strong bequest motive to insure his descendant against this risk.

\(^{20}\) The number of agents born in each skill group in period \( t \) depends only on the number of fathers in each skill group in period \( t - 1 \). We can iterate several times over \( \Phi(\cdot \mid i) \) for any given skill distribution. The skill distribution converges to the invariant distribution of a simple three-state Markov chain.
TABLE 1
Social mobility matrix $\Phi(i'|i)$

<table>
<thead>
<tr>
<th>Son's ability (t+1)</th>
<th>High-skill</th>
<th>Middle-skill</th>
<th>Low-skill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father's ability (t)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-skill</td>
<td>0.4077</td>
<td>0.3187</td>
<td>0.2736</td>
</tr>
<tr>
<td>Middle-skill</td>
<td>0.2191</td>
<td>0.3507</td>
<td>0.4302</td>
</tr>
<tr>
<td>Low-skill</td>
<td>0.0929</td>
<td>0.1952</td>
<td>0.7119</td>
</tr>
</tbody>
</table>

NOTE: A high-skill worker faces a 40.77% probability of giving birth to a high-skill type son.
SOURCE: Own computations from French LFS 1993

TABLE 2
Life cycle transition probabilities

<table>
<thead>
<tr>
<th>$\pi_Y$</th>
<th>High</th>
<th>Middle</th>
<th>Low</th>
<th>$\pi_A^{(†)}$</th>
<th>$\pi_O^{(†)}$</th>
<th>ERA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark and NDC</td>
<td>1/(34–22.2)</td>
<td>1/(34–19.5)</td>
<td>1/(34–17.4)</td>
<td>1/(54–35)</td>
<td>1/(58–55)</td>
<td>60</td>
</tr>
<tr>
<td>Ayrault</td>
<td>1/(34–22.2)</td>
<td>1/(34–19.5)</td>
<td>1/(34–17.4)</td>
<td>1/(54–35)</td>
<td>1/(60–55)</td>
<td>62</td>
</tr>
</tbody>
</table>

NOTE: (†) Same probability for all skill groups.

workers when they enter the labour market. The ages of entry into the workforce are 22.2, 19.5 and 17.4 for H-, M- and L-workers, respectively (Colin et al. 2000). As a proxy, we use the age of the end of education. Young workers are individuals who are between the beginning of their working life and age 34, thus the expected duration of time as a young worker is age 34 minus the skill-specific age of entry. Since the French pension formula depends on the number of contributive years during the work life, the age at first job affects the amount of pension benefits, and hence retirement choices. The second stage of the life cycle comprises adults aged 35 to 54. The third stage of the life cycle comprises older workers age 55 until a year prior to the ERA. During this period, they are not yet eligible for SS benefits and face non-employment risk. The life cycle transition probabilities are reported in table 2. From ERA onwards, individuals face a death probability that depends on the labour ability of the worker.\(^{21}\) Life expectancy at 60 years old equals 24.4, 20.7 and 18.6 years for H-, M- and L-workers, respectively (Charpin 1999). Blanchet and Monfort (1996) provide figures for life expectancy at age 65 but

\(^{21}\) As shown in figure B1 in the online appendix, we need to calibrate death probability at each age between ERA and 70. It would be possible if we had life expectancy, at each age between ERA and 70 for each skill group, which we could not find. However, we use the information on life expectancy at age 60 and 65 for the three skill groups and use inter/intrapolation to get values for each age in the model.
**TABLE 3**

French death probabilities between 59 and 70, before the increase in life expectancy

<table>
<thead>
<tr>
<th>Age</th>
<th>59</th>
<th>60</th>
<th>61</th>
<th>62</th>
<th>63</th>
<th>64</th>
<th>65</th>
<th>66</th>
<th>67</th>
<th>68</th>
<th>69</th>
<th>70+</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>0.043</td>
<td>0.044</td>
<td>0.046</td>
<td>0.048</td>
<td>0.050</td>
<td>0.052</td>
<td>0.054</td>
<td>0.056</td>
<td>0.059</td>
<td>0.062</td>
<td>0.065</td>
<td>0.068</td>
</tr>
<tr>
<td>M</td>
<td>0.049</td>
<td>0.051</td>
<td>0.053</td>
<td>0.056</td>
<td>0.058</td>
<td>0.061</td>
<td>0.064</td>
<td>0.068</td>
<td>0.071</td>
<td>0.075</td>
<td>0.080</td>
<td>0.086</td>
</tr>
<tr>
<td>L</td>
<td>0.056</td>
<td>0.059</td>
<td>0.062</td>
<td>0.065</td>
<td>0.068</td>
<td>0.072</td>
<td>0.076</td>
<td>0.081</td>
<td>0.087</td>
<td>0.093</td>
<td>0.100</td>
<td>0.109</td>
</tr>
</tbody>
</table>

**SOURCES:** Own computations from COR (2001) and Blanchet and Monfort (1996)

**TABLE 4**

Non-employment risk

<table>
<thead>
<tr>
<th>Unemployment</th>
<th>Earlywithdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment</td>
<td>Earlywithdrawal</td>
</tr>
<tr>
<td>$\pi_U$</td>
<td>$\theta_U$</td>
</tr>
<tr>
<td>$\pi_P$</td>
<td>$\theta_P$</td>
</tr>
<tr>
<td>H-type worker</td>
<td>0.0467 0.60</td>
</tr>
<tr>
<td>M-type worker</td>
<td>0.0433 0.59</td>
</tr>
<tr>
<td>L-type worker</td>
<td>0.0400 0.62</td>
</tr>
</tbody>
</table>

**NOTE:** Each period, an employed L-ability worker faces a 4.67% probability of entering a specific program of early withdrawal from the labour market.

only for men. This allows us to compute death probabilities between ages 60 and 65. Death probabilities (see table 3) display an exponential pattern that is consistent with Insee (1996). We check that the mortality profiles computed for each skill group are consistent with the aggregate mortality reported in Charpin (1999). Death probabilities increase with age but are lower when individuals have more skills. In the new steady state that we examine, life expectancy increases by six years at age 60 (COR 2001). We assume that all skill levels benefit evenly from the higher life expectancy.

### 3.1.3. Non-employment risks

We let $\theta_U$ ($\theta_P$, respectively) be the replacement ratio associated with French unemployment benefits, but only for programs specific to older workers. The replacement ratios are computed from the French LFS as averages within each skill level. $\pi_U$ refers to the probability of transition each year from employment to unemployment. $\pi_P$ denotes the probability of transition each year from employment to older workers’ specific programs. The annual transition rate from employment to non-employment is set such that the model replicates the employment and unemployment rates of male individuals aged 55–58 for each ability class (computed from the French employment survey in 1993; see table 4).

### 3.2. Calibrating life time careers and the pension system

#### 3.2.1. Wage profile

Using Insee (1999), we calibrate wages and labour efficiency $\mu_{ik}$ across age groups $k$ and skill levels $i$. The data from Insee (1999) are aggregated in order
to fit our age structure. Note that wage profiles are upward sloping with age. We calibrate values after taking into account the normalization to one of the young L-workers’ annual wages \(^{22}\) (see table 5). Between the first two periods of life, the wage growth factor is 1.24 for L-workers, 1.33 (=1.86/1.4) for M-workers and 1.52 (=3.25/2.14) for H-workers. Between the first and third periods of life, wage growth equals 1.26 for individuals in the low-skill group, 1.6 for the middle-skill group and 1.83 for the high-skill group. In contrast to L-workers, M- and H-workers are characterized by a steeper wage profile as they grow older.

### 3.2.2. Social security

Rather than relying on calibrated replacement rates, our computation of pensions is based on real-life formulas.\(^{23}\) Figure 2 illustrates the replacement rates for employed individuals, as they are predicted by the model under the benchmark economy before the pension reforms. Panel (a) reports the replacement ratio for the general regime, the first pillar of the pension system. Consistent with the data (Drees 2012), L-workers are characterized by the highest replacement ratios. Indeed, the presence of the SS cap in the Cnav pension formula limits the replacement ratio for H-workers whose wages are higher than the SS cap.

In regards to the age at which retirees are eligible for a full pension, H-workers reach the required number of contributive years at age 63, M-workers at 60 and L-workers at 58. However, the early retirement age was fixed at 60 in the 1990s. Therefore, it constitutes a binding constraint for

### Table 5

<table>
<thead>
<tr>
<th>Skill</th>
<th>Young</th>
<th>Adult</th>
<th>Old</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-skill</td>
<td>2.14(^a)</td>
<td>3.25</td>
<td>3.91</td>
</tr>
<tr>
<td>Middle-skill</td>
<td>1.40</td>
<td>1.86</td>
<td>2.25</td>
</tr>
<tr>
<td>Low-skill</td>
<td>1.00(^b)</td>
<td>1.24</td>
<td>1.26</td>
</tr>
</tbody>
</table>

**NOTES:**

\(^a\)A young high-skill agent’s annual wage is 2.14 times higher than a young low-skill agent’s annual wage.

\(^b\)The annual wage of low-skill young workers is normalized to one.

**SOURCE:** Insee (1999)

---

\(^{22}\)All variables in the paper will be then expressed in terms of this wage.

\(^{23}\)There are three key parameters in the SS system: the reference wage, the pension rate and the number of contributive years. Three payroll taxes are determined at the general equilibrium to balance the three separate budgets. The share of contribution rate paid by employers is 60%, against 40% for workers, which pins down \(\Theta_f(.)\) in the firm’s labour cost (equation (2)) and \(\Theta(.)\) in \(y(k,i,\xi)\) in households’ budget constraints.
L-workers who have to wait until age 60 before retiring. The general regime has no pension adjustments after the full-rate age (see figure 2, panel (a)). Therefore, for L- and M-workers, the SS pension is completely flat after the full pension age, even in the case of delayed retirement beyond the full pension age. H-workers bear a steep decrease in pension if they retire before the full rate reached at age 63, and if they want to postpone retirement beyond age 63, they would get no increase in pension.

Panel (b) in figure 2 displays the replacement ratios for the total pension (including MCSs). Since MCSs are based on NDC plans, delaying retirement increases the pension while retiring before the full pension leads to a steeper fall in replacement ratios as MCSs add a downward adjustment in the case of early retirement. The kinked profile of replacement ratios in figure 2 suggests that individuals have little choice in terms of retirement age. For instance, H-workers have no incentive to claim benefits before age 63 for fear of a dramatic fall in pension and little incentive to retire beyond 63 because the increase in pension is low. The Ayrault reform aimed at dampening the kinks in the profile of replacement ratios by lowering the penalty in the case of early retirement and increasing the reward in the case of delayed retirement. The model will predict whether individuals will be responsive to these new incentives.

3.3. Preferences and technology
Following Charpin’s 1999 report and OECD (2000), the technological trend is set to 2% a year in the case of France. Labour’s share of output is set to 0.64
and the depreciation rate is 10%, as in Hairault et al. (2008). The discount factor is set to 0.96. Such a parameter value makes the model consistent with the observed real interest rate and capital–output ratio (see section 3.4.1).

We set $\hat{\sigma}=2$, which is consistent with Attanasio et al. (1999) and Fuster et al. (2003). Assuming that eight hours per 24-hour day are devoted to labour, we get $1-\overline{t}=2/3$. The unemployed and retirees enjoy full-time leisure ($l=1$).

In the benchmark calibration, the altruism parameter is set to $\varrho=0.9$ in order to replicate the ratio of annual flows of intergenerational transfers, which are defined as the sum of unintended transfers plus bequests, to aggregate wealth. This ratio amounts to 2.3% (Arrondel and Laferrere 2001, Insee 1998). With $\varrho=0$, the ratio of annual flows of intergenerational transfers to aggregate financial wealth falls down to 1.1%, which is half its empirical counterpart. The ratio of bequests to aggregate wealth is sensitive enough to the altruism parameter to be confident in the calibrated value.\footnote{In online appendix D3, we report the model’s predictions in an economy without altruism ($\varrho=0$).}

In order to pin down the value of leisure $\eta$, Hairault et al. (2008) estimate the parameter such that the model replicates the fact that 95% of male individuals retire with the full pension rate. Such a calibration also allows us to match the elasticity of retirement response to the pension reforms prior to 1993 (Blanchet and Pelé 1999, Drees 2003). The distribution of retirement age prior to reform captures this feature in the model (see figure 3). This estimation procedure leads to $\eta=0.62$ for France, which is close to the value of 0.77 in Huggett and Ventura.
TABLE 6
Calibrated parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour's share of output $\alpha$</td>
<td>0.64</td>
</tr>
<tr>
<td>Depreciation rate $\delta$</td>
<td>10%</td>
</tr>
<tr>
<td>Growth productivity $\gamma$</td>
<td>2%</td>
</tr>
<tr>
<td>Discount rate $\beta$</td>
<td>0.96</td>
</tr>
<tr>
<td>Risk aversion coefficient $\sigma$</td>
<td>2</td>
</tr>
<tr>
<td>Leisure of worker $1 - l$</td>
<td>2/3</td>
</tr>
<tr>
<td>Weight of leisure in utility $\eta$</td>
<td>0.62</td>
</tr>
<tr>
<td>Altruism $\varrho$</td>
<td>0.90</td>
</tr>
</tbody>
</table>

(1999) on US data with similar preferences. We assume that the leisure parameter is similar across skill groups. Hence, differences in retirement behaviour across skill groups will not be generated by differences in preferences. Table 6 summarizes the calibration.

3.4. Model fit

The model’s predictions and data are reported in table 7. In this table, we compare column A (French data in the 1990s) to column B (economy in the 1990s). Scenario B will also be referred to as the “benchmark.”

3.4.1. Macroeconomic performances

The model is able to match the capital to output ratio. The equilibrium interest rate that equalizes asset supply to capital demand is 4.98%, which is very close to the average real French interest rate of 5%.

3.4.2. Pension: Distribution of retirement age, dependency ratio and contribution rates

Consistent with our comments on replacement ratios (see section 3.2.2), all individuals retire when they reach the age of full pension (63 for H-workers, 60 for other workers; see figure 3). This prediction of the model echoes the fact

25 The capital–output ratio found in the model is consistent with the data. $K/Y = 2.6$ in Caballero and Hammour (1999) and 2.2 in Villa (1995). Moreover, 2.4 corresponds to the ratio we found using Vikram and Dhareshwar’s (1995) data on the French physical capital stock in the post-1955 period. Given the calibration of capital depreciation, population growth and technological growth, the implied investment-to-output ratio is 0.29. This is close to the investment-to-output ratio of 0.28 found using the OECD National Accounts for France for the period 1990–2014. We do not report the consumption-to-output ratio, as it is simply the complement to the implied investment-to-output $1 - \delta K/Y$. This is matched by the model. Finally, the average real interest rate of 5% was found using the difference between the long-term interest rate and the CPI (all items) inflation, both time series extracted from OECD Key Short-term Economic Indicators database, annual data for the 1990–2014 period.
TABLE 7
Data and model’s predictions

<table>
<thead>
<tr>
<th></th>
<th>1990s data</th>
<th>Bench. 1990s</th>
<th>2040</th>
<th>Ayrault</th>
<th>NDC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
<td>(C)</td>
<td>(D)</td>
<td>(E)</td>
</tr>
<tr>
<td><strong>Macroeconomic performances</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Interest rate</td>
<td>0.05</td>
<td>0.0497</td>
<td>0.0478</td>
<td>0.0475</td>
<td>0.0455</td>
</tr>
<tr>
<td>2. $K/Y$</td>
<td>2.40</td>
<td>2.40</td>
<td>2.44</td>
<td>2.44</td>
<td>2.47</td>
</tr>
<tr>
<td><strong>Pension</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Increase in life expectancy</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>4. Dependency ratio 1990</td>
<td>0.44</td>
<td>0.4486</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Dependency ratio 2040</td>
<td>0.64</td>
<td>0.64</td>
<td>0.50</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td><strong>Contribution rate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Contribution rate: High</td>
<td>0.16</td>
<td>0.23</td>
<td>0.19</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>7. Contribution rate: Middle</td>
<td>0.13</td>
<td>0.18</td>
<td>0.15</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td>8. Contribution rate: Low</td>
<td>0.12</td>
<td>0.17</td>
<td>0.14</td>
<td>0.12</td>
<td></td>
</tr>
<tr>
<td><strong>Inequalities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Gini assets</td>
<td>0.73</td>
<td>0.75</td>
<td>0.74</td>
<td>0.75</td>
<td>0.81</td>
</tr>
<tr>
<td>10. Constrained agents: Total</td>
<td>0.22</td>
<td>0.25</td>
<td>0.23</td>
<td>0.25</td>
<td>0.37</td>
</tr>
<tr>
<td>10(i). Constrained agents: High</td>
<td>0.0576c</td>
<td>0.0485</td>
<td>0.0573</td>
<td>0.1885</td>
<td></td>
</tr>
<tr>
<td>10(ii). Constrained agents: Middle</td>
<td>0.3467</td>
<td>0.3338</td>
<td>0.3394</td>
<td>0.1312</td>
<td></td>
</tr>
<tr>
<td>10(iii). Constrained agents: Low</td>
<td>0.4685</td>
<td>0.4407</td>
<td>0.4364</td>
<td>0.6613</td>
<td></td>
</tr>
<tr>
<td>11. Bequest-to-total-asset ratio</td>
<td>0.0234</td>
<td>0.0234</td>
<td>0.0207</td>
<td>0.0210</td>
<td>0.0198</td>
</tr>
<tr>
<td>12. Average bequest: High</td>
<td>2.16d</td>
<td>1.35</td>
<td>2.46</td>
<td>5.46</td>
<td></td>
</tr>
<tr>
<td>13. Average bequest: Middle</td>
<td>0.52</td>
<td>0.32</td>
<td>1.06</td>
<td>1.76</td>
<td></td>
</tr>
<tr>
<td>14. Average bequest: Low</td>
<td>0.22</td>
<td>0.12</td>
<td>0.23</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>15. Gini income</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
<td>0.30</td>
<td>0.33</td>
</tr>
<tr>
<td>16. Gini consumption</td>
<td>0.25–0.30</td>
<td>0.25</td>
<td>0.24</td>
<td>0.25</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Welfare: Compensating variations (welfare improving with respect to economy C if negative)

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>17. High</td>
<td>−0.0401e</td>
<td>−0.0046f</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Middle</td>
<td>−0.0269</td>
<td>0.0513</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Low</td>
<td>−0.0210</td>
<td>0.0735</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Total</td>
<td>−0.0241</td>
<td>0.0645</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTES: 

- Contribution rates of prime-age workers are defined as sum of the employee’s contributions (Cnav, Arrco, Agirc) divided by gross wage.
- 25% of agents in the economy have zero assets.
- Among H-workers, 5.77% have zero assets.
- The average bequest of an H-worker is 2.16 times the annual wage of a young L-worker.
- H-workers in scenario D have the same welfare as in scenario C if, in economy D, their income goes down by 4.01%: switching from C to D increases their welfare.
- H-workers in scenario E have the same welfare as in scenario C if, in economy E, their income goes down by 0.46%: switching from C to E increases their welfare.

that, in the 1990s, 95% of male retirees had indeed accumulated the required number of contributive years (Drees 2003).

26 The value of leisure $\eta$ was calibrated to match this salient feature of retirement choices in France, prior to reforms. Since we disregard heterogeneity in the length of contributing years at the same age within each labour ability class, health status, specific female participation and incomplete careers, the model cannot capture the complete distribution of retirement ages. However, we replicate the stylized fact that agents retire mostly as soon as the full rate is available.
The dependency ratio, defined as the number of retirees divided by the number of individuals in the labour force both employed and non-employed, equals 44.86% in the model (see table 7, row 4, column B), which is close to the 44% observed in France in the 1990s (Belhaj 2004, Charpin 1999).

We actually compute three payroll taxes for the three separate pension plans ($\tau_{\text{Cnav}}, \tau_{\text{Arrco}}, \tau_{\text{Agirc}}$). For the sake of brevity, we report in table 7, rows 6–8, only a contribution rate that is defined as the sum of an employee’s contribution divided by the gross wage for prime-age workers. We check that the benchmark model (B) yields endogenous contribution rates that are consistent with observed levels. Workers’ equilibrium contribution rate to the general regime equals 8.35% versus 6.55% in the data (as reported in Charpin 1999). For complementary schemes, the equilibrium rates paid by workers are respectively 3.32% (and 8.30% $\tau_{\text{Agirc}}$) in the model versus 3% (and 8% $\tau_{\text{Agirc}}$) in the data. Because of the SS cap in the collection of contributions, the profile of contribution rates is non-linear in earnings. The model is reasonably close to the data with respect to the dependency ratio and the contribution rates in the benchmark economy, which suggests that the model can be considered a good proxy to capture the age structure, retirement patterns and resulting strains on PAYG budgets.

### 3.4.3. Wealth and consumption distribution

Data on wealth distribution in France in the 1990s are reported in column A of table 7, rows 9–14. The Gini coefficient on wealth is based on computation from the 1998 French wealth survey, *l’enquête Patrimoine*. The fraction of liquidity-constrained agents with zero assets in the French economy is taken from Arrondel (2002). The Gini coefficient on income in the 1990s is 0.276, from OECD (2015). The model fits the other dimensions well (column B of table 7, rows 9, 10 and 15). The model also replicates salient features of the wealth distribution (online appendix D1). In row 16, we report the Gini coefficient on consumption.27 The Gini predicted by the model lies within the range consistent with the data (see column B, row 16). Note we have not used the distribution of consumption as part of our calibration targets. Therefore, any similarities between the model economy and the data along this dimension can be considered to provide further evidence of the model fit.

### 4. Distributional and welfare effects of SS reform

#### 4.1. Increase in life expectancy without pension reform

We first compare columns B and C in table 7. In economy C, life expectancy at age 60 goes up compared to economy B, and the PAYG system is balanced only with an endogenous increase in the SS contribution rate. Since the pension

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27 For want of French data, we report in column A the Gini coefficients on US and UK data as reported in Castañeda et al. (2003) and Blundell (2011), respectively.
formula is not changed, the distribution of retirement ages in economy C is similar to the one in economy B (see figure 3), and the increased distortionary labour tax makes working less attractive. With agents retiring at the same age and living longer in retirement, the dependency ratio goes up to 64%, which is consistent with the worsening of the dependency ratio predicted by COR (2001); the model can thus be considered a good tool to capture aging and the resulting strain on PAYG budgets. SS is balanced only through a significant increase in contribution rates for the general regime and MCSs: the overall pension contribution rate goes up from 16% to 23% for prime-age H-workers, from 13% to 18% for M-workers and from 12% to 17% for L-workers.

Our model is consistent with the Charpin (1999) report predictions. The predictions of the model regarding dependency ratio and contribution-rate changes, without pension reforms, are also consistent with the projections in official reports (COR 2001, Charpin 1999). For instance, the overall contribution rate needs to increase by approximately 50% when moving from economy B to economy C in order to balance the PAYG system given the foreseeable increase in life expectancy. This suggests that our quantitative exercise can also be considered a good proxy for the French economy, incorporating a foreseeable increase in life expectancy but without change in the pension system. With the increase in the contribution rates, workers cannot save as much as in the benchmark economy B. The average bequest falls for all skill groups (see columns B and C, rows 12–14). The available capital in the economy falls with no increase in labour supply because individuals do not delay retirement. As a result, aggregate output goes down. The increase in $K/Y$ in table 7, row 2, is driven by the fall in output.

4.2. Ayrault reform

The Ayrault reform (see table 7, column D) increases the early retirement age by two years, i.e., from age 60 to 62, for all individuals. Postponing the retirement age by two years and then using payroll taxes to finance the remaining burden reduces the size of the fiscal burden and, therefore, the size of the additional tax required to finance it compared to economy C (columns C–D, rows 6–8).

The retirement distribution mechanically shifts to the right (see figure 4, panel (a), as compared to figure 3, panel (a)). The reform also alters the profile of replacement ratios. Figure 2 displays the replacement ratio as a function of retirement age for economies C, D and E by skill group. Without reform, the replacement ratio for L-workers (see panel (c)) displays a kink at age 60, the age of full pension. With the change in the early retirement age, the kink is now at age 62. The increase in the number of contributive years, from 40 to 43, does not shift the age of full pension beyond 62 because L-workers start their work life at an early age (see calibration in section 3.1.2) and thus accumulate the required years prior to age 62. Therefore, it is not surprising that the model predicts that all L-workers retire at age 62 (see figure 4).
FIGURE 4 Retirement age after Ayrault reform


Without reform, the replacement ratio for H-workers displays a kink at age 63, their age of full pension (see figure 2, panel (a)). The Ayrault reform increases the full pension age to 66 by increasing the number of contributive years from 40 to 43. The kink at the full pension age (66 in economy D) is not as apparent as that in the economy without reform (age 63, in economy C), because the Ayrault reform changes the early-retirement penalty and the late-retirement bonus. The model predicts that, with this new pension formula, all H-workers retire at age 66 (see figure 4, panel (a)): H-workers are sensitive to the fall in pension before age 66 but are not responsive to the rewards offered for working longer.

Interestingly, for M-workers, the retirement age is heterogeneous. With the increase in the number of contributive years, the full pension age is now at 63, which is the first peak on figure 4, panel (a), corresponding to the retirement of all non-employed M-workers (panel (c)). These workers are not entitled to the late-retirement pension bonus. This first peak is also due to some M-workers who are not willing to delay retirement (panel (b)). The second peak at age 64 comes only from employed M-workers who are willing to work beyond the full pension age (panel (b)) and get the corresponding pension bonus. The model predicts that these individuals represent 13% of retirees, consistent with the 14% reported in Drees (2014). 28 The reason behind the willingness to postpone lies in altruism. M-workers face the risk of lower productivity for

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28 The pension bonus for late retirement was actually introduced prior to the Ayrault reform, so that there are first estimates available of the impact of this incentive on retirement decisions.
their children, i.e., lower ability and wages. In order to insure against this risk, they are willing to work an additional year to accumulate savings, and hence a bequest. In table 7, column D, row 13, the bequest of M-workers significantly increases compared to the benchmark economy (column C).

Our analysis shows that all elements of the Ayrault reform contribute to delayed retirement in economy D. The increase in the number of contributive years shifts the retirement peak for H- and M-workers—with the latter somewhat responsive to the late-retirement pension bonus—while the increase of the early retirement age to 62 is particularly important for L-workers. The latter greatly contributes to the good performance of the Ayrault reform in terms of dependency ratio, as L-workers make up over 50% of retirees (see figure 4, panel (a)); delayed retirement significantly lowers the dependency ratio compared to economy C, from 50% to 64% (see table 7, row 5).

The welfare differences between economies C and D are measured using compensating variations. $\tilde{W}_C$ denotes the ex ante welfare of a young agent computed in economy C, as in Imrohoroglu et al. (1999). This value function takes into account all possible future outcomes during the life cycle, including individual risks and intergenerational skill changes:

$$\tilde{W}_C = \int_a \Phi(i'|i)V(a,Y,i,E)\lambda(a,Y,i,E)da.$$
The same computation is done for economy D, yielding $\tilde{W}_D$. Compensating variations measure the amount of money that individuals in economy D must be given to accept being in the new economy (D) rather than in the reference economy (C). The monetary compensation is measured in terms of percentage change in income given to individuals, each year and at all ages, for them to accept the switch.

For all agents, compensating variations are negative (see table 7, column D, rows 17–20), i.e., all agents require a lower income in economy D than in economy C to keep their welfare unchanged. Switching from economy C to economy D thus improves welfare. Indeed, with delayed retirement, the contribution rate need not increase as much as in economy C to balance the PAYG system (columns C–D, rows 6–8). All agents would prefer economy D as it combines delayed retirement with a limited increase in the contribution rate, rather than a full adjustment on the contribution rate as in economy C. H-workers are particularly keen on staying in economy D (columns C–D, row 17), since the difference in the contribution rate between economies C and D is larger for this skill group (columns C–D, row 6).

4.3. Hypothetical NDC system

The model predicts a much more dispersed retirement age distribution (see figure 6) if France were to switch to an NDC scheme. L-workers, whether employed or not, could retire at the early retirement age of 60 as they had been able to do in economies B and C. Since they represent more than 50%
of retirees, the 58% dependency ratio in economy E (row 5) is not very far from the 64% one in economy C. These workers would not have any incentive to delay retirement to accumulate wealth for their children. An L-worker is already at the bottom of the ability distribution, and his child can only go up or stay at the parent’s ability level. Without any strong bequest motive, L-workers are not enticed to delay retirement and they leave little bequest (column E, row 14). Their bequest is even less than that under the Ayrault reform, as their pension falls substantially (see figure 2, panel (c)).

Interestingly, the retirement age distribution for M- and H-workers displays heterogeneity within each skill group because of the pension formula. As seen in figure 2, panels (a) and (b), with an NDC reform, the replacement ratios no longer display any kink. This gives agents more flexibility to choose their retirement age. Retirement at an early age yields a slight decrease in pension, while a delayed retirement age equally yields a slight increase in pension. Altruism is an important driver of wealth accumulation in the model. The existence of earnings risks at birth underlies why altruistic older individuals want to work longer in order to have more income for their descendants. This fear of a descending ability change for their children is particularly true for H- and M-workers, who are higher on the scale of ability levels. Table 1 shows that an H-worker has a 60% chance of giving birth to a child of lower ability while for an M-worker it is 43%. The bequests of H- and M-workers are therefore higher than that of L-workers, in all columns of table 7, rows 12–14. The bequest motive is particularly strong in column E. This dispersion in wealth distribution translates into dispersion in the distribution of retirement age.29 Richer agents retire earlier because their wealth compensates for their lower pensions.

4.4. Additional considerations

4.4.1. Understanding the interaction between wealth and retirement choices

The model yields an array of wealth thresholds above which individuals of each ability category decide to retire (see table 8). For instance, an M-worker who considers retiring at age 60 must have current wealth greater than 8.95 in order to cease working. Given the normalization considered in our model, this threshold corresponds to three years of that individual’s current net wage. These value functions intersect when financial holdings are equal to a threshold asset level $A^*$.30 We indicate the share of employed workers within each skill group who decide to retire at a given age in table 8 (columns 2, 4 and 6). For instance, 4.2% of employed H-workers are wealthy enough ($A > A^*$) to retire at age 60. The interaction between wealth and retirement decisions yields a

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29 We check this intuition in online appendix D3 by examining the predictions of the model in the absence of altruism.

30 Figure C1 in the online appendix illustrates the interaction between wealth accumulation and retirement that affects individual retirement decisions.
TABLE 8
Wealth accumulation and retirement decisions: Examining the example of employed workers

<table>
<thead>
<tr>
<th>Age</th>
<th>H*(1)</th>
<th>H fraction (2)</th>
<th>M*(3)</th>
<th>M fraction (4)</th>
<th>L*(5)</th>
<th>L fraction (6)</th>
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<tr>
<td>60</td>
<td>31.97</td>
<td>0.0420</td>
<td>8.95</td>
<td>0.1309</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>61</td>
<td>31.91</td>
<td>0</td>
<td>8.17</td>
<td>0.0105</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>62</td>
<td>31.28</td>
<td>0</td>
<td>8.48</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>63</td>
<td>27.94</td>
<td>0.0103</td>
<td>8.79</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>64</td>
<td>23.45a</td>
<td>0.0309b</td>
<td>6.58</td>
<td>0.0223</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>65</td>
<td>21.36</td>
<td>0.0135</td>
<td>4.58</td>
<td>0.0452</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>66</td>
<td>21.62</td>
<td>0</td>
<td>2.96</td>
<td>0.0661</td>
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<td>0</td>
</tr>
<tr>
<td>67</td>
<td>20.11</td>
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<td>1.37</td>
<td>0.3986</td>
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<td>68</td>
<td>16.16</td>
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<td>69</td>
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<tr>
<td>70</td>
<td>0</td>
<td>0.8193</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

NOTES: 
a. Retirement decision of the H-type employed worker: If his current assets are larger than 23.45, he retires. Otherwise, he keeps working.
b. The percentage of employed H-workers retiring at age 64 is 3.09.

more unequal distribution of assets. The Gini on assets goes up from 0.75 to 0.81 (see table 7, columns B and E, row 9).

Under an NDC scheme, the increase in inequalities appears strong at the bottom of the asset distribution. The fraction of agents without assets goes up from 23 to 37% (see table 7, columns C and E, row 10). This increase in the fraction of liquidity-constrained agents is unevenly distributed (column E, rows 10(i) to 10(iii)). Nearly two thirds of L-workers have zero assets, against 43% in economy C. At 13% in economy E, fewer M-workers are liquidity-constrained than in economy C (33%). Indeed, M-workers delay retirement to accumulate assets for bequest motives. The Gini on income, defined as the sum of earnings and capital income, goes up from 0.29 to 0.33. The Gini on consumption goes up as well to 0.28 (column E, row 16).

4.4.2. Choice of a contribution rate and distributional effects
The NDC system yields significant welfare losses; individuals would have to be given 6.45% more income to accept the switch from economies C to E (see table 7, column E, row 20). The welfare loss is particularly large for L-workers, with a 7.35% compensating variation. The reason behind this uneven distribution of welfare losses does not lie in the contributive rates—as shown in column E, rows 6–8, the contribution rate of 12% is actually the lowest of all scenarios and, as in the NDC reform, the contribution rates are equalized across skill groups. The unequal welfare loss is due to the fall in replacement ratios associated with the NDC reform; figure 2 indicates that replacement ratios are lowest under this reform. The pension decrease is particularly strong for L-type workers at age 60, their retirement age. As the
pension is the sum of capitalized contributions on wages, wage inequalities throughout the work life translate directly into inequalities in pensions. The unequal income distribution, resulting from an unequal distribution of assets, also plays a role in generating uneven consumption and welfare.

Since the fall in replacement ratios plays a major role in the fall of welfare, why not increase the pension? The pension is directly derived from the contributions made during the work life of an individual. In order to increase the pension, the policy-maker would need to increase the contribution rate, which could also hurt L-workers during their work life because they include the largest fraction of financially constrained agents (see table 7, column E, row 10(iii)) and because they rely mostly on labour income. They have a lower income, lower consumption and, hence, higher marginal utility. The contribution rate must also be high enough to bring in revenue but not too high because a higher contribution rate also means increasing the pension. An NDC scheme makes the choice of a contribution rate a difficult exercise. The predictions of the model point to the fact that, under an NDC reform, the financial viability of the French PAYG system leads to a moderate contribution rate, i.e., 12% for employees with low pensions (column E, rows 6–8).

5. Conclusion

Our exercise uses a model with endogenous retirement and wealth that captures the changes in effective retirement age that French governments may try to induce through SS reforms. Individuals in the model are heterogeneous with respect to their skill level (low, middle, high), age, employment status and asset holdings. Focusing on long-term distributional effects provides a first assessment of the welfare effects of different SS reform scenarios across a group of heterogeneous individuals. To achieve this, we construct and analyze four scenarios.

In the first scenario, a “benchmark economy” is examined, without any potential increase in life expectancy and without any reforms taking place. The model predictions are then compared to the data for France in the 1990s, providing a satisfactory match. In the second scenario, an increase in life expectancy is introduced but without pension reform. Financial sustainability of SS is achieved only through an increase in the contribution rate. We check that the demographic predictions of the model are close to the official projections for France in 2040.

We then study two pension reform scenarios: the 2013 Ayrault reform, which combined an adjustment in the contribution rate with a change in legal retirement age, and a hypothetical change to an NDC system. The paper presents two significant results based on comparisons made with respect to a reference economy in which increases in life expectancy occur and are dealt with only through higher contribution rates. First, on aggregate welfare, the Ayrault reform and the hypothetical switch to NDC yield contrasting
results. The Ayrault reform improves aggregate welfare, which is not the case for the NDC reform. With respect to this reference economy, the Ayrault reform combines a delayed legal retirement age and a smaller increase in the contribution rate. This combination is preferred by all individuals to a larger increase in the contribution rate without reform. In contrast, the hypothetical switch to NDC yields negative aggregate consequences, with individuals requiring a 6.45% increase in income on average to support the reform. This is due to the drastic fall in replacement ratios.

Second, both reforms yield unequal distributions of welfare changes, with low-skill workers on the losing end. Under the Ayrault reform, L-workers delay retirement by two years, to age 62. Under NDC reform, pensions for low-skill workers fall substantially as inequalities during the work life translate directly into inequalities in pensions. With a change to NDC, pensions would fall drastically and individuals would be compelled to save more. However, since low-skill workers do not save as much as middle- or high-skill workers, the switch to an NDC scheme leads to a more unequal society in terms of asset and welfare distribution. In that sense, the paper does not support Bozio and Piketty’s (2008) call for implementing an NDC scheme in France.

References


Blundell, R. (2011) “From income to consumption: Understanding the transmission of inequality,” mimeo, University College London


Supporting information

Additional supporting information can be found in the online version of this article.