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Social security, education, retirement and growth*

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Abstract

This paper analyzes, firstly, the expected effects of social security reforms that have been implemented in Spain after 2004 (and, secondly, the expected effects of reductions in the minimum pension) on retirement decision and human capital accumulation (and hence on growth and on income inequality). Individuals in our model economy differ in their innate ability and growth is a by-product of the most skilled individuals' productivity. According to our model, *i*) increases in the minimum and normal retirement ages are expected to have a strong effect, not only on individuals' retirement decisions, but also on their education investment; *ii*) augmented incentives to late retirement are not expected to have any effect; *iii*) reductions in the minimum pension are not expected to have a significant effect unless it is completely eliminated.

Keywords: Social Security; Pay-as-you-go; Voluntary Retirement; Human Capital; Minimum Pension.

JEL classification: O4, H3.

1. Introduction

A great deal of literature has analyzed the effect of *pay-as-you-go social security* on workers' *voluntary retirement age*. The available empirical evidence suggests that, at least for the US economy, social security is relevant for retirement age issues, despite the lack of

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total agreement on the effect of changes in the payout from the social security program. (See, *e.g.*, Diamond *et al.,* 1997, Coile *et al.,* 2000, Fabel, 1994, Fenge and Pestieau, 2005, Kalemli-Ozcan, 2002.).

However, very few papers study the effect of a *minimum pension* upon workers' voluntary retirement age. For instance, according to the calculations in Jiménez-Martín and Sánchez-Martín (2007) and Sánchez (2010) on the role of minimum pensions in postponing early retirement in Spain, total early retirement was almost 50% larger with minimum pensions. As they were considering an *exogenous growth* model, they could not, of course, analyze the effect of minimum (or maximum) pensions on growth.

Some papers have explored the impact of a *pay-as-you-go social security* system on *human capital investment incentives*, and hence on *endogenous growth*. For instance, Echevarría and Iza (2006) obtained a discouraging effect of the size of social security on human capital accumulation and retirement age. Furthermore, the relationship between the size of social security and the per capita *GDP* growth rate that they found was mostly negative, except for very low values for the social security contribution rate. The explanation lies in the discouraging effect that social security imposes on education and, in particular, retirement age, which causes a fall in the share of the working population in the economy. However, they did not consider the effect of *minimum* (or *maximum*) *pensions* on *education* and *growth*.

In this paper, we focus on the effects of a minimum pension payment in a pay-as-you-go social security system on human capital (education) investment incentives, and hence, on growth and income inequality. Additionally, retirement age is endogenously determined, so we also analyze the effects of pension policies on early retirement incentives. We build up a two-period, *OLG* model economy in which pension benefits are earnings-related and populated by *ex ante* heterogeneous individuals who differ in their innate (learning) ability.

Individuals in their first period of life choose their level of education. Those born with higher ability are expected to invest more in their education. Assuming [which is the case, among others, of the Spanish social security system] that pension payments are earnings-related, the return on human capital investment is not constrained to labor income while working, but in fact extends to pensions during retirement[1]. Therefore, when individuals choose their optimal level of education, they take into account not only the effect on future labor earnings, but also on future pension benefits. Consequently, social security introduces an incentive for higher investment in human capital[2].

This incentive, however, might break down because the pension scheme includes a minimum pension payment[3]. For instance, as the minimum pension increases, so does the threshold for the innate ability for which individuals end up receiving the minimum pension. Minimum pensions, therefore, have a discouraging effect on education investment for those individuals with sufficiently low innate ability. In their second period, individuals supply labor elastically (*i.e.* optimally choose their retirement age). Therefore, voluntary retirement age also depends on the incentives embedded in the public pension system: not only minimum pensions, but also *penalties* for early retirement which take the form of reductions in the net pension payment if retirement occurs *before normal* retirement age, and the *incentives* for retiring *after normal* retirement age. Minimum pensions work in the opposite direction to penalties and incentives as they promote early retirement. In short, social security in this economy influences both the size of the working population in the economy and its productivity.

We calibrate the model and construct a benchmark case which fairly reproduces some stylized facts of the Spanish economy in 2004. Starting from this baseline case, firstly, we solve for a new balanced growth path economy taking into account social security policies already in place or projected to be implemented in the near future (higher minimum and normal retirement ages and higher incentives to late retirement). We analyze their effects on retirement, education investment (and hence, on internal rate of return of the pension system, income inequality and growth) under two scenarios: i) assuming the same educational distribution of workers and dependency ratio as observed in 2004, and ii) considering a new stationary educational distribution of workers and dependency ratio to which the Spanish economy is expected to converge by 2050. Thirdly, we analyze the effects of reductions in the minimum retirement pension benefits under the above mentioned two scenarios. Our main results follow:

I. Our model predicts that more skilled individuals enjoy a higher return on their investment in education and, consequently, spend more on education.
II. The existence of a minimum pension, however, may reduce low skill individuals' incentives to invest in human capital.
III. Increases in the minimum and normal retirement ages are expected to have a strong effect, not only on individuals' retirement decisions, but also on their education investment.
IV. Augmented incentives to late retirement are not expected to have any effect.
V. Reductions in the minimum pension are not expected to have a significant effect unless it is completely eliminated.
VI. Policies enhancing human capital investment for the cleverest workers increase growth as a by-product of these workers' productivity.

The paper is organized as follows: Section 2 describes the economy. The calibration and the corresponding numerical exercise are carried out in Section 3. Section 4 presents the conclusions. A mathematical Appendix is included at the end.

2 The economy

This economy is characterized by the behavior of households and firms which act in perfectly competitive markets for one unique (aggregate) commodity and two production factors (physical capital and human capital) in the presence of social security. Time is discrete.

2.1. Households

At any time t this economy is populated by two overlapping generations of individuals, young and old. Individuals consume both when young and old, and supply inelastically one unit of labor when young. In their second period, however, individuals choose their optimal leisure consumption: higher leisure consumption is interpreted as workers choosing to retire earlier[4]. Second period leisure is modeled as a continuous variable choice, bounded both above and below, so that a whole range of intermediate choices is possible. A similar setup is used in Garriga and Manresa (1999).

Additionally, individuals in their first period must choose their optimal level of education: this choice will affect not only their labor income, but also their retirement pension benefits. This is so because we assume that *i*) social security is *non-funded*, and *ii*) pensions are *earnings-related* (and, therefore, defined-benefit type).

We assume one unique source of heterogeneity among individuals. Thus, we assume that there are four types of individuals (i = 1, 2, 3, 4) who differ by their innate ability, θ_i (where $\theta_1 < \theta_2 < \theta_3 < \theta_4$): higher innate ability means higher learning ability and higher return on investment in human capital and, therefore, higher education expenditure in principle (which, in turn, implies higher economic growth). Types 1, 2, 3 and 4 represent individuals with no primary studies, individuals attaining primary, secondary (high school) and college education, respectively.

This heterogeneity drives the income inequality in this economy, partially mitigated by the social security system[5]. As will be seen, the existence of minimum pension benefits, along with the earnings-related nature of pension benefits, might pose an incentive problem: low-skill individuals might find it optimal to reduce their investment in education for a sufficiently high minimum retirement pension. The preferences of an i-th type individual born at time t are represented by the utility function

$$u\left(c^i_{y,t}, c^i_{o,t+1}, \ell^i_{t+1}\right) = \ln c^i_{y,t} + \beta\left(\ln c^i_{o,t+1} + \xi \ln \ell^i_{t+1}\right), \qquad [1]$$

where $\beta > 0$ stands for the discount factor, $c^i_{y,t}$ and $c^i_{o,t+1}$ denote first period and second period consumption, $\xi > 0$ represents the second period relative preference of leisure upon consumption, and $\ell^i_{o,t+1} \in [\ell^L, \ell^U]$ denotes second period leisure. We assume that second period leisure is bounded below ($\ell^L > 0$), *i.e.* workers are legally forced to retire at some time before a maximum age; and, also, bounded above ($\ell^U < 1$), *i.e.* a minimum retirement age exists[6]. Whenever an individual choice variable is affected by two subscripts, the first one denotes the individual's age (y for young and o for old, respectively), and the second one denotes calendar time.

We assume the productivity level, h^i_t, this individual attains is a function of his/her innate ability, θ_i, and his/her expenditure on education, e^i_t, once normalized by the total factor productivity at time t, A_t. More precisely, we assume that

$$h_t^i = \theta_i \left[1 + \left(e_t^i / A_t \right)^\gamma \right], \quad \gamma \in (0,1). \qquad [2]$$

As in Bouzahzah, De la Croix and Docquier (2002) [*BDD* hereafter], the engine of growth of this economy will be given by the aggregate state of knowledge in the economy. Even though our model is very close to the one in *BDD*, the way in which we separate the individual human capital level from the state of knowledge is in fact closer to Romer (1990), as we distinguish between the *private* knowledge attained by an individual who lives a finite life, h_t^i, and the *non-rival* knowledge of the economy which can be accumulated indefinitely, A_t.

Education expenditure is normalized by the state of knowledge in Eq. (2) in order to obtain a balanced growth path of the economy along which the wage (per unit of labor) grows at the same rate as the total factor productivity, A_t. Therefore, the expenditure on education will increase at the same rate as A_t, and all individuals of type i will spend a constant share of their income on education, so that both e_t^i / A_t and h_t^i remain constant too; and the *total* productivity will be $h_t^i A_t$, growing at the same rate as A_t.

A major difference between our model and the one in BDD is that investment in education comes from income rather than time. A second difference between the two models is that we treat retirement age as endogenous: we believe that a thorough understanding of all the incentives embedded in social security systems entails considering the retirement decision as a choice variable.

The first period budget constraint is given by

$$c_{y,t}^i + s_{y,t}^i + e_t^i = w_{n,t} h_t^i A_t, \qquad [3]$$

where $s_{y,t}^i$ denotes savings, $w_{n,t} \equiv (1 - \tau_t^{ss}) w_t$ denotes the net of social security contribution wage rate per efficient unit, τ_t^{ss} denotes the social security contribution rate (*i.e.* the pay-roll tax rate), and w_t denotes the wage rate per efficient unit[7].

The second period budget constraint is given by

$$c_{o,t+1}^i = \left(1 + r_{t+1}\right) s_{y,t}^i + \ell_{t+1}^i b_{t+1}^i + \left(1 - \ell_{t+1}^i\right) w_{n,t+1} h_t^i A_{t+1} + ss_{t+1}, \qquad [4]$$

where $w_{n,t+1} \equiv (1 - \tau_{t+1}^{ss}) w_{t+1}$, r_{t+1} denotes the interest rate between periods t and $t+1$, b_{t+1}^i stands for the social security retirement pension benefit (per unit of time), and ss_{t+1} denotes the lump-sum transfer that old individuals receive as a result of sharing the difference between social security contributions minus retirement pension payments[8]. Given the redistributive role played by social security, where income is mainly transferred from the young (workers) to the old, we assume that the difference between contributions and pensions in our model is transferred to individuals in their second period. Note that both the pension benefit and the labor income that the individual is paid in his/her second period are conveniently weighted by leisure time and labor time, ℓ_{t+1}^i and $1 - \ell_{t+1}^i$, respectively[9].

As for the retirement pension, two cases must be considered in turn: *i*) retirees whose pension benefit is the result of applying a replacement rate τ^{rep}_{t+1} to past earnings and either a before-normal-age-retirement penalty, q^i, or an after-normal-age retirement incentive, Φ^i; and *ii*) retirees who, otherwise, would be receiving a too low pension under the previous scheme, and who are paid a minimum pension, b^{min}_{t+1}. Thus, this second type of retirees' pension benefit becomes earnings-*unrelated*[10]. Formally, retirement pension for an *i*-th type individual at time $t+1$ is given by[11]

$$b^i_{t+1} = \begin{cases} b^{\min}_{t+1}, \; for \;\; \Phi^i q^i \tau^{rep}_{t+1} w_t h^i_t A_t < b^{\min}_{t+1} \\ \Phi^i q^i \tau^{rep}_{t+1} w_t h^i_t A_t, \;\; otherwise. \end{cases} \quad [5]$$

Concerning the first case, we assume that the replacement rate applies to the average labor income obtained during the first active periods. If the economy grew at a non-zero per capita rate, for a balanced growth path to exist, pension benefits should grow at the same rate at which per capita variables grow. Concerning Eq. (5) two remarks are in order. *Firstly,* we assume that the before-normal-age retirement penalty and the after-normal-age retirement incentive only apply to individuals whose retirement pensions are earnings-related. *Secondly*, we assume that the (absence of) penalty, q^i, is a linear function *decreasing* in ℓ^i_{t+1},

$$q^i = \begin{cases} 1, & if \;\; \ell^L \leq \ell^i_{t+1} \leq \ell^N \\ 1-\alpha_1\left(\ell^i_{t+1} - \ell^N\right), & if \;\; \ell^N < \ell^i_{t+1} \leq \ell^U \end{cases} \quad [6]$$

where $\alpha_1 \equiv (1-\alpha_0)/(\ell^U - \ell^N)$, $\alpha_0 \in (0,1)$, $\ell^N \in (\ell^L, \ell^U)$, denoting the leisure corresponding to the normal-retirement-age. Thus, a worker retiring at the minimum retirement age (so that $\ell = \ell^U$) would be paid a fraction $q = \alpha_0$ of the pension that he/she would obtain, otherwise, if he/she retired at or after normal retirement age (*i.e.* if $\ell \leq \ell^N$). Additionally, for an early retirement penalty rate per year, π, one has that α_0 is given by

$$\alpha_0 = 1 - \pi\left(R^N - R^{\min}\right), \quad [7]$$

where R^N and $R^{\min}$ denote normal retirement age and minimum retirement age, respectively[12]. *Thirdly*, in order to evaluate the social security reforms implemented after 2004, we will consider the late-retirement-age incentives. In particular, we assume that the incentive Φ^i is a linear function decreasing in ℓ^i_{t+1},

$$\Phi^i = \begin{cases} 1, & if \;\; \ell^N < \ell^i_{t+1} \leq \ell^U \\ 1+\alpha_2\left(\ell^N - \ell^i_{t+1}\right), & if \;\; \ell^L \leq \ell^i_{t+1} \leq \ell^N \end{cases} \quad [8]$$

where α_2 denotes the extra pension payment for remaining in the labor force after reaching the normal-retirement-age.

Thus, assuming away borrowing constraints, the problem that an i-th type individual faces can formally be expressed as the maximization of Eq. (1) with respect to $c^i_{y,t}$, $c^i_{o,t+1}$, $s^i_{y,t}$, ℓ^i_{t+1} and e^i_t, subject to Eqs. (2), (3), (4), (5), (6) and (8). Additionally, it must be the case that $\ell^L \leq \ell^i_{t+1} \leq \ell^U$. For the sake of clarity, the set of first order necessary conditions for this problem can be presented in two parts: *firstly*, we show the condition that determines the optimal e^i_t (and b^i_{t+1}), which is equivalent to that one that maximizes the difference between the sum of the discounted value of first and second period earnings (pension benefits included), minus the education expenditure[13]. And, *secondly*, we show the conditions for optimal, $c^i_{y,t}$, $c^i_{o,t+1}$, $s^i_{y,t}$, and ℓ^i_{t+1}. The optimal values for all choice variables are obtained, of course, by solving all the conditions simultaneously[14].

- **Optimal education and retirement pension.** The optimal solution for education expenditure depends on whether the retirement pension that the retiree gets paid is earnings-related or not. Thus, it can be shown that if the pension benefit does depend on the labor income that the individual obtained when he/she was a worker, the optimal education and pension payment are given by

$$e^i_t = e_{1,t}(\theta_i) \equiv A_t \left\{ \gamma\theta_i \left[w_t \left(1 - \tau^{ss}_t + \frac{\Phi^i q^i \tau^{rep}_{t+1} \ell^i_{t+1}}{R_{t+1}} \right) + \frac{w_{n,t+1}(1+\lambda_t)(1-\ell^i_{t+1})}{R_{t+1}} \right] \right\}^{\frac{1}{1-\gamma}} \quad [9]$$

and $b^i_{t+1} = \Phi^i q^i \tau^{rep}_{t+1} w^i h^i_t A_t$, respectively, where $\lambda_t \equiv (A_{t+1} - A_t) / A_t$, *i.e.* the growth rate of the total factor productivity, and $R_{t+1} = 1 + r_{t+1}$ [15]. As expected, and along balanced growth paths, $e_{1,t}(\theta_i)$ grows over time with A_t and depends positively on the net wage rates per efficiency unit and the pension replacement rate. A higher discount factor reduces the discounted value of retirement pensions and second period labor income, so that it reduces the incentive to invest in education or human capital. Last but not least, $e_{1,t}(\theta_i)$ depends positively on θ_i: more skilled individuals enjoy a higher return on their investment in education and, consequently, are expected to spend more on education. This is a well known result in human capital literature. (See Le Garrec, 2005 and references there in.) Later we characterize the range of values of θ for which optimal education is given by (9).
The existence of a minimum retirement pension, however, might break the link between education expenditure and retirement pension benefits. Individuals with a skill level below some lower bound $\underline{\theta}_t$ might find it optimal to get paid just the minimum pension and invest in education accordingly (*i.e.* less). In this case, it can be shown that the optimal education and pension payment are given by

$$e^i_t = e_{2,t}(\theta_i) \equiv A_t \left\{ \gamma\theta_i \left[w_{n,t} + \frac{w_{n,t+1}(1+\lambda_t)(1-\ell^i_{t+1})}{R_{t+1}} \right] \right\}^{\frac{1}{1-\gamma}}, \quad [10]$$

and $b^i_{t+1} = b^{min}_{t+1}$, respectively, for all $\theta_i < \underline{\theta}_t$. Of course, as long as $\Phi^i q^i \tau^{rep}_{t+1} \ell^i_{t+1} > 0$, it must be the case that $e_{1,t}(\theta_i) > e_{2,t}(\theta_i) > 0$. Thus, our model predicts that the existence

of a minimum pension may reduce the incentives of low skill individuals to invest in human capital acquisition. Note also that $e_{2,t}(\theta_i)$ is increasing in θ_i. Therefore, a lower bound for the skill parameter must exist. Once $\theta_i \geq \underline{\theta}_t$, the retirement pension becomes earnings-related. Taking into account that [given the utility function in Eq. (1)] optimal ℓ^i_{t+1} is *strictly positive*, $\underline{\theta}_t$ is implicitly given by $\Phi^i q^i \tau^{rep}_{t+1} w_t h_t(\underline{\theta}_t) A_t = b^{min}_{t+1}$.
For the sake of completeness, Figure 1 shows how optimal education and pension payment are related to θ_i and where a discontinuity of e_i at $\theta = \underline{\theta}$ shows up: starting at a low θ, when the learning ability parameter equals $\underline{\theta}$, education expenditure jumps upwards[16].

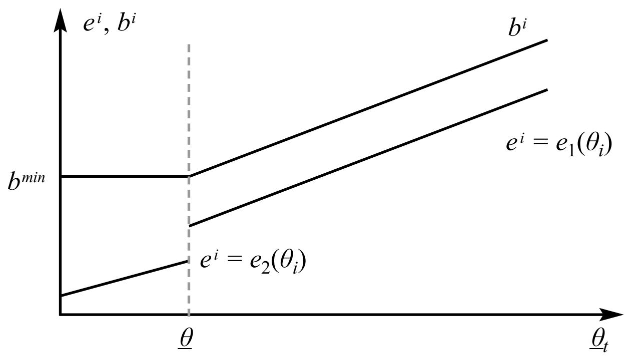

Figure 1

- **The other optimal decisions: consumption, savings and leisure**. The rest of first order necessary conditions for an interior solution are given by

$$\frac{1}{c^i_{y,t}} = \frac{\beta R_{t+1}}{c^i_{o,t+1}} \qquad [11]$$

$$\frac{\xi c^i_{o,t+1}}{\ell^i_{t+1}} = w_{n,t+1} h^i_t A_{t+1} - b^i_{t+1} - \ell^i_{t+1} \frac{\partial b^i_{t+1}}{\partial \ell^i_{t+1}}, \ \ for \ \ \ell^L < \ell^i_{t+1} < \ell^U, \qquad [12]$$

where

$$\frac{\partial b^i_{t+1}}{\partial \ell^i_{t+1}} = \begin{cases} 0, & if \ \ \ell^L < \ell^i_{t+1} < \ell^N \ \ or \ \ b^i_{t+1} = b^{\min}_{t+1} \\ \dfrac{-\alpha_1 b^i_{t+1}}{q^i}, & if \ \ \ell^N < \ell^i_{t+1} < \ell^U \ \ and \ \ b^{\min}_{t+1} < b^i_{t+1} \\ \dfrac{-\alpha_2 b^i_{t+1}}{\Phi^i}, & if \ \ \ell^L < \ell^i_{t+1} < \ell^N \ \ and \ \ b^{\min}_{t+1} < b^i_{t+1} \end{cases} \qquad [13]$$

where h_t^i is given by Eq. (2) and, of course, the optimal e_t^i will in general depend on ℓ_{t+1}^i, plus the first and second period budget constraints in Eqs. (3) and (4) respectively. The interpretations of Eqs. (11) and (12) are the usual ones. Eq. (13) represents how the choice of the retirement age affects the pension payment.

2.2. Aggregate labor force

We assume an exogenous, constant population growth rate $n \geq 0$, so that the proportions of young and old individuals are given by $\mu_y = (1+n)/(2+n)$, and $\mu_o = 1/(1+n)$, respectively. Additionally, we assume that the exogenous distribution of skills among the population is such that the proportion of individuals of type i is given by $\{\psi_i\}_{i=1}^4 \geq 0$, where $\sum_{i=1}^4 \psi_i \equiv 1$. Denoting by P_t the total population at time t, aggregate labor force supply is given by

$$L_t = \mu_y P_t \sum_{i=1}^{4} \Psi_i h_t^i + \mu_o P_t \sum_{i=1}^{4} \Psi_i h_{t-1}^i \left(1 - \ell_t^i\right). \qquad [14]$$

The first term on the right-hand-side of Eq. (14) represents the labor force of young individuals, and the second term stands for the labor force of old individuals. In this latter case the retirement decision is crucial.

2.3. Social security

The social security budget equation at any time t is given by

$$\tau_t^{ss} w_t L_t A_t = P_t \mu_o \left[\sum_{i=1}^{4} \Psi_i b_t^i \ell_t^i + ss_t \right], \qquad [15]$$

where the left-hand-side represents total revenue, and the right-hand-side denotes total expenditure on retirement pensions plus lump-sum transfers. Both social security revenues and payments on retirement pensions depend on *i*) the age structure of the population, *ii*) the distribution of skill levels, and *iii*) (as in the case of the aggregate labor force) the distribution of retirement ages across old individuals.

2.4. Firms

Regarding the production sector, we assume the existence of a representative, competitive firm which produces one unique output, Y_t, out of physical capital, K_t, and human capital in *efficiency units,* $A_t L_t$, and which maximizes current profits. Formally, assuming Cobb-Douglas production technology, it faces the following problem

$$\max_{\{K_t, L_t\}} Z K_t^{\alpha} \left(A_t L_t\right)^{1-\alpha} - w_t A_t L_t - \left(r_t + \delta\right) K_t, \qquad [16]$$

where $Z > 0$ is a scaling factor of the technology level, $\alpha \in (0,1)$ denotes the elasticity of output with respect to physical capital, and $\delta \in (0,1)$ stands for the physical capital depreciation rate.

The productivity of the labor force here depends on two *independent* factors: *i*) the state of knowledge of the economy, A_t, and ii) the individuals' human capital level[17], h_t^i, which in turn depends on ii.1) their innate ability, θ_i, and ii.2) their investment in education, e_t^i, which allows individuals to increase their human capital level above their innate ability.

The first order necessary (and sufficient) conditions for the problem in Eq. (16) give us the factor price equations

$$w_t = (1-\alpha) Z k_t^{\alpha} \quad and \quad r_t + \delta = \alpha Z k_t^{\alpha-1}, \tag{17}$$

where $k_t \equiv K_t / (A_t L_t)$, *i.e.* the stock of physical capital per efficient unit of labor.

2.5. Goods market equilibrium

As in Diamond (1965), the condition for equilibrium in the goods market states that the aggregate savings of the young generation at any time *t* must equal the stock of physical capital installed in the economy at time *t* +1. Formally, and denoting type-*i* young individual's savings by $s_{y,t}^i$, we have that

$$\mu_y P_t \sum_{i=1}^{4} \Psi_i s_{y,t}^i = K_{t+1}. \tag{18}$$

2.6. Growth

We assume that the growth rate at time *t* of the total factor productivity, A_t, is given by

$$\lambda_t = \rho h_t^4 > 0, \tag{19}$$

for some $\rho > 0$. Thus, we are assuming that growth is a by-product of the young cleverest or type-4 agents' individual human capital, h_t^4. Note that Eq. (19) implies that this growth model is not of vintage type. It is an analogous specification to the one in *BDD* with two differences: *i*) we assume heterogeneity of innate abilities, and *ii*) we allow for different technologies for *individual* and *social* human capital accumulation. A similar specification to that in Eq. (19) has been used by Caucutt et al. (2003) where growth is a by-product (an externality) of hiring skilled workers. Once the model is set up, we solve the equilibrium for this economy. In order to do so, some (quantity) variables must be first redefined relative to efficiency units so that all these redefined variables remain constant on a balanced growth path. We have normalized the individual variables by the total factor productivity, A_t, [which on a balanced growth path grows at a constant rate equal to λ] and the aggregate variables by the aggregate labor force in efficiency units, A_tL_t, [which also grows at a constant rate $(1 + \lambda)(1 + n) - 1$ on a balanced growth path]. The stationary steady state equilibrium can be solved as a system of simultaneous nonlinear equations with the help of some numerical techniques[18]. (See Appendix A.)

As a by-product, our model allows us to study the redistributional role played by the social security and its eventual conflict with individual incentives to labor supply, retirement and economic growth. We focus on one particular measure of (in)equality such as Gini's index relative to the sum of discounted life-time net income,

$$w_n h^i + \frac{\hat{b}^i \ell^i (1+\lambda)}{R} + \frac{w_n h^i (1+\lambda)(1-\ell^i)}{R},$$

which we denote by I_G.

3. A numerical example

3.1. Calibration

The non-linearity of the model and the number of equations involved (in spite of its simple dynamic structure) prevent us from obtaining analytical results for the solution to the individual problem, let alone for the general equilibrium problem, so that uniqueness must be assumed. Therefore, we have to rely on numerical analysis for which we need some basic values for preferences, technology, demographics and social security policy. Our aim when choosing values is simply to illustrate qualitatively the working and the main features of our model, but approaching to some extent certain observed figures of the Spanish economy in a base year, 2004, taking into account the Spanish social security policy features in that year.

- **Demographics**. We assume that each of the two periods in the model represents about 32.5 years. According to the INE[19], and following Díaz-Giménez and Díaz-Saavedra (2009a,b), we choose the value for the population growth rate to mimic the observed dependency ratio in 2004, which gives a value for n equal to 0.3.[20]
- **Preferences.** As for preferences, the subjective discount factor is set at $\beta = 2.0$. This means that the yearly preference discount factor equals $\beta^{1/32.5} = 1.021556$, slightly higher than others found in the literature[21]. For instance, Conesa and Garriga (1999) set it at 0.985, and Garriga and Manresa (1999) at 0.987.
  The leisure-related parameter in the utility function ξ is set equal to 0.209. This value has been chosen so that type-1 individuals choose to retire at the minimum retirement age, (*i.e.* at $R^{\min} = 60$), and type-2, type-3 and type-4 individuals choose to retire around normal retirement age (*i.e.* at $R^N = 65$), (64.7, 64.8 and 65.0, respectively)[22]. Jiménez-Martín and Sánchez-Martín (2007) and Antón et al. (2007) show that retirement hazard rate clearly exhibits two peaks: at 60 and at 65.

As for ℓ^L and ℓ^U, assuming that individuals start solving their maximization problem at the age of 15 and that their deterministic life expectancy is $80 = 2 \times 32.5 + 15$, the upper bound ℓ^U equals 0.615, which corresponds with a minimum retirement age of 60 years [*i.e.* $\ell^U = (80-60)/32.5$]. The lower bound ℓ^L is set at 0.308, thus representing a compulsory retirement age of $R^{\max} = 70$ years [*i.e.* $\ell^L = (80-70)/32.5$].

- **Heterogeneity of individuals' innate ability.** Concerning the values of innate abilities, we normalize $\theta_1 = 1$, and we pick up the values for θ_2, θ_3 and θ_4 taking into account that the higher the innate ability, the higher the educational attainment. In short, we make a one-to-one correspondence between individuals' innate abilities and their educational attainments. We set θ_2 so that the ratio of type-2 workers' hourly wage rate to that of type-1 workers fairly replicates the observed ratio of the annual earnings of workers with primary education to that of workers earning the minimum legal wage (annual earnings) (*i.e.*, that we are assuming that annual hours are the same for all workers). In particular, in Spain in 2002[23], this ratio equals 2.25, and θ_2 is set equal to 2.0807. Concerning the value for θ_3 we choose its value such that the ratio of hourly wage rate of type-3 workers' to that of hourly wage rate of type-2 workers is equal to 1.38, and θ_3 is set equal to 2.776. Analogously, to set θ_4 we consider that the ratio of the hourly wage rate of workers with college education to that of workers with high school education is the same as the observed ratio. This value was equal to 1.52 in Spain in 2002, and θ_4 is set equal to 4.0387 Furthermore, this way we are able to obtain in our benchmark case *i*) the two types of pension benefits: minimum, for type-1 individuals, and earnings-related, for type-2, type-3 and type-4 individuals; and *ii*) the two types of education expenditure: e_2, for type-1 individuals, and e_1, for type-2, type-3 and type-4 individuals.
  As for the distribution of the skill parameter, we assume a constant intra-generational distribution that mimics the observed distribution of the workers regarding their retirement age and pension benefits. We use the projections of the educational distribution provided by Díaz-Giménez and Díaz-Saavedra (2009a,b), which follow Messeguer (2001)'s projections, to obtain the educational distribution of working-age population in Spain in 2004. In particular, we choose the value for ψ_1 so that the proportion of retirees receiving the minimum pension is close to the observed value[24]. Thus, we assume that $\psi_1 = 0.2784$. The value for $\psi_2 = 0.3094$ is chosen as the difference between the proportions of workers with primary education and those pensioners receiving the minimum pension. The proportion of working-age population with high school, which is equal to the proportion of type-3 individuals, is $\psi_3 = 0.26$. Trivially, the value for ψ_4 is equal to $1.0 - \psi_1 - \psi_2 - \psi_3$ that mimics the proportion of working-age individuals with college in Spain in 2004. Finally, as regards human capital production, we assume that $\gamma = 0.35$.[25]
- **Social security system**. We assume that $\hat{b}^{\min} = 0.095$. The minimum pension is chosen to capture that the minimum pension received by type-1 individuals is approximately equal to their hourly wage rate. In Spain, the minimum pension is around 100% the minimum wage. In our model, type-1 individuals receive the minimum

wage[26]. Jiménez-Martín and Sánchez-Martín (2007) mentions that 70% of workers retiring at 60 are low-income workers who receive the minimum pension. As all type-1 individuals are homogeneous in our model, we obtain that all type-1 individuals receive the same (the minimum) pension.
We set $\tau^{ss} = 0.283$ thus equating the observed value[27]. We do not consider sources of revenues other than contributions (such as transfers and subsidies, financial asset income or sale of real estate and financial assets).
We assume that for those workers whose pension benefits are earnings-related and who retire after the normal retirement age, R^N, (*i.e.* at the age interval [65, 70]), their replacement rate is equal to one. However, there are individuals whose replacement rate is below one. In particular, those who retire before the normal retirement age and are penalized accordingly. Replacement rate for individual i is obtained as $\hat{b}^i_{t+1}(1 + \lambda_t)/(w_t h^i_t)$, so that the average replacement rate along balanced growth paths is given by $ARR = [(1 + \lambda)/w] \sum_{i=1}^{4} \psi_i\, (\hat{b}^i / h^i)$.[28]
Observed replacement rates vary depending on the life experience of workers. For an average worker, pension represents 81.2% of average earnings[29]. We obtain a value equal to 1.07. For the sake of comparison, Conesa and Garriga (1999) obtain 0.72. As for inequality, the Gini index equals 0.2539.[30]
Defining the (balanced growth rate) internal rate of return for individual i, IRR^i, as that rate of return for which the sum of discounted values of his/her contributions equals the sum of discounted values of his/her pension payments, IRR^i is given by

$$0.53\tau^{ss} w h^i + \frac{0.53\tau^{ss} w h^i (1+\lambda)(1-\ell^i)}{1+IRR^i} = \frac{\hat{b}^i (1+\lambda)\,\ell^i}{1+IRR^i}. \qquad [20]$$

Following Jimeno and Licandro (1999), we adjust the contribution rate τ^{ss} by the coefficient 0.53, because the expenditure on retirement pensions approximately represents a 53% share of total contributive pensions.
Remembering 1 period in our model represents 32.5 years, an approximate measure of the annualized social security internal rate of return for individual i can be given by $irr^i = (1+IRR^i)^{1/32.5} - 1$. We obtain that $irr^1 = 4.81\%$, $irr^2 = 2.243\%$, $irr^3 = 2.241\%$ and $irr^4 = 2.237\%$; this yields a weighted average of 2.956%. Jimeno and Licandro (1999) claim that the observed values range between 3.7% and 5.03% [depending on the number of active (contributed) years, retirement age and life expectancy]. As expected, the internal rate of return is higher for type-1 individuals (*i.e.* those receiving the minimum pension) and lower for type-4 individuals. Be aware that in this economy, even though the contribution and replacement rates are constant, the existence of the minimum pensions means that the Social Security system is progressive.

- **The penalty and incentive parameters.** As for α_0 and α_1 in the penalty function, Eqs. (6)-(7), setting normal retirement age, R^N, equal to 65, and minimum retirement age, $R^{\min}$, equal to 60, and an 8% penalty per year of advanced retirement, π, makes $\alpha_0 = 0.6$. On the other hand, remembering, once more, our period convention and that individuals are assumed to become optimizing agents at 15, $\ell^N = 1-(R^N - 47.5)/32.5$

= 0.462. As a result of the values assigned to α_0 , ℓ^U and ℓ^N, one obtains that α_1 = 2.6. As for α_2, the extra pension payment for remaining in the labor force after reaching the normal-retirement-age, this is set to 0.0.

- **Production technology parameters**. Concerning production technology, the participation of capital income in total income is set equal to $\alpha = 0.375$, as in Conesa and Garriga (1999). The depreciation rate of physical capital is set at $\delta = 1-(1-0.045)^{32.5} = 0.778$, as in Conesa and Kehoe (2004). The scaling factor Z is set at 1.00.
- **Growth**. Finally, with respect to the growth parameter, we assume $\rho = 0.376$. We are therefore able to replicate the observed yearly per capita growth rate of 0.02 [what implies that $\lambda = (1+0.02)^{32.5}-1 = 0.903$].

Table 1 summarizes the parameters calibrated for the benchmark case, and compares simulated and observed values for the magnitudes calibrated. Table 2 summarizes those parameters not calibrated.

Table 1
BENCHMARK CASE: PARAMETERS CALIBRATED[31,32]

	Parameter	Value	Target Variable	Target Value	Model Value
Sample size	n	0.300	*(ret/act)*[a]	0.25	0.25
Preferences	ξ	0.2090	$[R_1,R_2,R_3,R_4]^b$	[60,65,65,65]	[60,64.7,64.8,65]
Ability	θ_2	2.0807	$(wh_2 / wh_1)^c$	2.25	2.25
	θ_3	2.7760	$(wh_3 / wh_2)^d$	1.38	1.38
	θ_4	4.0387	$(wh_4 / wh_3)^d$	1.53	1.53
	ψ_1	0.2784	$share_1^e$	0.2784	0.2784
	ψ_2	0.3094	$share_2^f$	0.3094	0.3094
	ψ_3	0.2600	$share_3^g$	0.2600	0.2600
	ψ_4	0.1522	$share_4^h$	0.1522	0.1522
Social Security	$\hat{b}^{\min}$	0.095	$\hat{b}^{\min} / (wh_1)$	[0.85,1.14]	0.95
	α_0	0.600	α_0	0.600	0.600
	α_1	2.600	π	0.08	0.08
	α_2	0.000	α_2	0.00	0.00
	ℓ^L	0.308	$R^{\max}$	70.0	70.0
	ℓ^U	0.615	$R^{\min}$	60.0	60.0
	ℓ^N	0.462	R^N	65.0	65.0
Growth	ρ	0.164	λ_{annual}^i	0.02	0.02

The calibrated structural parameters in col. 2 are those introduced in the text. Col. 3: values assigned to such parameters. Col. 4: targeted variable. Col. 5: targeted value in the benchmark economy (i.e. year 2004) and, finally, Col. 6: simulated value in the model economy.
[a]*: ratio of population older than 65 to working age population.*
[b]*: type-i individual's optimal retirement age.*
[c]*: ratio of the gross hourly wage rate of type-2 individuals to that of type-1 individuals, the latter assumed to be paid the minimum wage;*
[d]*: ratio of the gross hourly wage rate of type- j individuals to that of type-i individuals, for j = 3, 4 and i = 2, 3;*
[e]*: proportion of retirees who are paid the minimum pension;*
[f]*: proportion of retirees with primary school educational attainment and pension above the minimum;*
[g]*: proportion of retirees with secondary school educational attainment, and*
[h]*: proportion of retirees with college educational attainment.*
[i]*: λ annual: annualized per capita GDP growth rate.*

Tabla 2
BENCHMARK CASE: PARAMETERS NON CALIBRATED

	Parameter	Values
Preferences	β	2.00
Ability	θ_1	1.00
Learning	γ	0.35
Technology	α	0.375
	Z	1.00
	δ	0.778
Social Security	τ^{ss}	0.283
	τ^{rep}	1.00

3.2. Findings

We perform some numerical exercises to see what our theoretical model predicts about the response of the economy (in terms of incentives of human capital investment and early retirement) upon reductions in the minimum pension. Given the social security budget balance constraint in Eq. (15), whenever the minimum pension is reduced, the difference between social security contributions and retirement pensions, *ss*, is conveniently adjusted while the social security contribution rate is kept constant at the benchmark case value[33]. Results are summarized in table 3.

Four caveats concerning the way in which we present our results are in order. Firstly, we have evaluated the effects of any decrease in the minimum pension assuming that 1) the new minimum retirement age is 63 years old, 2) the new normal retirement age is 67 years old, and that 3) the premium for each extra year working after the normal retirement age is 3%, as these are new social security policies either already implemented after the benchmark year, or projected to be implemented in the near future[34]. Secondly, we evaluate the individual and aggregate effects of decreasing the minimum pension under two scenarios: assuming that the educational distribution of the working-age population and the dependency ratio remain at their initial value in the benchmark balanced growth path [scenario 1]; and, alternatively, that these are close to those expected values in a hypothetical new balanced growth path [scenario 2].

The figures for the latter scenario are taken from Díaz-Giménez and Díaz-Saavedra (2009a, 2009b) who use the projections in Messeguer (2001). In particular, they consider that the educational distribution in Spain will converge to a new steady state by, approximately, 2050. This new educational distribution will be given by: $\psi_1^{NBGP} = 0.1800$, $\psi_2^{NBGP} = 0.20$, $\psi_3^{NBGP} = 0.38$ and $\psi_4^{NBGP} = 0.24$. In order to obtain ψ_1^{NBGP} and ψ_2^{NBGP}, we have assumed that the ratio $\psi_1 / (\psi_1 + \psi_2)$ remains constant across both balanced growth paths, as the projections in Messeguer provide figures for the sum of $\psi_1 + \psi_2$. The new value set for n is equal to zero, which gives a dependency ratio higher than in 2004, but lower than the one expected for 2050, as the expected population growth rate for that year is negative (which is not compatible with the existence of a balanced growth path).

Thirdly, as we have pointed out above, some reforms have already been implemented since 2004 because they *are* part of the projected reform for 2011 (the delay in the normal retirement age, the increase in the minimum retirement age [fully effective in 2027] and the 3% bonus). Consequently, before starting with the analysis of the effect of reducing the minimum pension, we analyze what our model would predict about the new balanced growth path if no more reforms took place. And afterwards, we look at what our model would predict if, additionally, reductions in the minimum pension were also set in place.

Fourthly, we distinguish between partial and general equilibrium effects. The general equilibrium effects will come from two sources. On the one hand (even in the absence of any change in the minimum pension), the changes in the minimum legal and normal retirement ages and in the late-retirement incentive will make pension expenditures decrease and contributions increase. This will be the case since workers will end up retiring later. Consequently, *ss* (which we will refer to as the social security surplus in the sequel) will rise, thereby making individuals' second period income higher what, in turn, decreases savings. On the other hand, pension payments for type-2, type-3 and type-4 workers remain earnings-related. As we will see, penalties for early retirement will be higher for those individuals (despite postponing retirement!). Therefore, these individuals will have incentives to increase their savings. We will see that net effect on young individuals' savings (and k and factor prices), will critically depend on the educational distribution. Thus, for the n and ψ's in the initial balanced growth path, it turns out that k is predicted to fall; while for those in the expected new balanced growth path, k is predicted to rise, as the proportions of type-3 and type-4 individuals go higher.

As already mentioned above, we first analyze the individual and aggregate effects of the new minimum legal and normal retirement ages and the new premium for late retirement without any change in the minimum pension whatsoever, because these reforms have already been implemented after 2004. And, next, we analyze the additional effects of changes in the minimum pension. In both cases, we evaluate such effects under the two above mentioned scenarios. Results are shown in table 3.

- **New balanced growth path with reforms already implemented after 2004.** *Scenario 1: Initial educational distribution and dependency ratio*. (See table 3, column 4) Type-1 individuals respond by retiring at the new minimum legal retirement age, so that their incentive to education increases. Type 2 to 4 individuals end up retiring later than in the benchmark economy, but *quite before* the new normal retirement age. Even though type-1 individuals' education investment rises, their internal rate or return falls as so does their retirement length. Concerning type 2 to 4 individuals, the response of their education investment and internal rate of return are (mainly) explained by general equilibrium effects. As mentioned above, the resulting higher social security surplus (lump-sum distributed to old age individuals) causes individuals' first period savings decrease. But, at the same time, type 2 to 4 individuals increase their first period savings as pension payments are earnings-related and their penalties for early retirement *rise*. As it turns out, the net effect on k is negative, so that both the net wage rate and the discount factor get lower, thereby decreasing the incentives to education investment. (See Eqs. (9) and (10).) This implies a negative effect on the $\hat{e}$'s, for all type of workers except for type-1 individuals, for which the mentioned above partial effect dominates. The internal rates or return for type 2 to 4 individuals decrease more than for type-1 individuals. This is so because pension payments for type 2 to 4 are lower (retirement pensions are earnings-related, labor income falls, penalties for early retirement are higher and, finally, pension payments are more heavily discounted). As for type-1 individuals, however, they receive the same (minimum) pension, but for a shorter time span. Income inequality decreases relative to the benchmark case. Labor income rises for type-1 individuals, since their education investment rises, but their pension benefits remain constant. However, for the rest of individuals, education investment becomes lower and so do their labor incomes and pension payments. Therefore, the dispersion of labor earnings (pensions interpreted as deferred labor earnings) is necessarily reduced. Finally, the fall in type-4 individuals' education fully explains the fall in the growth rate per capita output.

Scenario 2: New educational distribution and dependency ratio. (See table 3, column 8) Type-1 individuals retire at the new minimum legal retirement age, of course. Concerning the rest of individuals, they retire later than in the benchmark economy, as expected, and slightly later than in scenario 1, but, once again, before the new normal retirement age. Comparing results with those in scenario 1, type-1 individuals increase their educational investment in a much higher proportion. This is so because the general equilibrium effect now *reinforces* the positive partial effect. The final explanation comes from the fact that with a higher proportion of qualified workers in scenario 2, the net effect on k is positive now, thereby increasing the education investment incentives for all types of workers. Concerning the internal rates of return, the falls for type 2 to 4 individuals are similar to those in the scenario 1. The decrease in the internal rate for type-1 individuals now is higher: even though the same pension payment is less discounted, social security contributions are higher as wages are also higher due to the positive effect on k. As for the income inequality, this falls more than in the first scenario, because the proportions of lower income individuals (θ_1 and θ_2) fall and, of course, the proportions of higher income individuals (θ_3 and θ_4) rise. Lastly, the increment in type-4 individuals' education explains the predicted increment in per capita growth.

- **Reductions in minimum pension.** *Scenario 1: Initial educational distribution and dependency ratio*. Consider, firstly, reductions in the minimum pension so that type-1 workers still find it optimal to retire at the (new) minimum legal retirement age, and (of course) be paid the minimum pension. In particular, when minimum pension drops 10.0% or 15.0%. (See table 3, columns 5 and 6). This policy reform affects directly type-1 individuals. The (quite similar) predicted increment in these individuals' educational investment is explained the same way as above. Concerning general equilibrium effects, there is an additional source stemming from the reductions in $\hat{b}^{min}$. On the one hand, social security pension expenses are reduced and, consequently, the social security surplus must increase more (See how $\Delta rest$ is higher for higher $\hat{b}^{min}$ drops along last row in table 3), thereby decreasing savings. But, on the other hand, the minimum pension received by type-1 individuals is lower, what makes them increase their savings. In sum, type-1 individuals are experiencing two opposite sign equilibrium effects: as we move in table 3 from column 4 to 6, the decrement in k is lower[35]. Consequently, the fall in incentives to education investment will be lower too, which implies a lower negative effect on the $\hat{e}$'s for all types of workers. Therefore, the increase in the education investment for type-1 workers is higher than with no reductions in the minimum pension, and the decrease for the rest of individuals is lower. Regarding the internal rate or return, the one for type-1 individuals drops more as the reductions of the minimum pension are larger. For type 2 to 4 individuals, as expected, their return rates are hardly affected by drops in the minimum pension. The inequality index decreases less as the minimum pension is reducing. This seemingly counterintuitive result, however, has a neat explanation: despite minimum pensions fall, type-1 individuals increase their human capital investment so that their labor incomes are higher.

Consider, secondly, reductions in the minimum pension so that type-1 workers do not find it optimal to retire at the minimum retirement age any more. Once the minimum pension is not binding, the reform would be equivalent to one in which the minimum pension is removed. Therefore, we evaluate the effect of eliminating the minimum pension (See table 3, column 7). Needless to say, type-1 individuals are by far the most affected. A sharp increase in $\hat{e}^1$ shows up: the minimum pension disappears and the pension payment becomes earnings-related; once this happens, the returns to (the incentives of) education investment and the incentive to postpone retirement rise. For the rest of individuals, the retirement age decision does not change, and the education investment decreases more than in the case of no reductions in the minimum pension. This is so because the social security surplus becomes larger, thereby inducing the by now familiar (negative) general equilibrium effects on savings, capital per worker and factor prices. Additionally, the income inequality "decreases" less than in the case that the reductions in the minimum pension remain binding for type-1 individuals, of course: type-1 individuals greatly increase not only their labor incomes, but also their (now) earnings-related pension benefits; and, moreover, type 2 to 4 individuals' productivities and labor incomes decrease in a higher magnitude. Finally, since growth is determined as a by-product of type-4 workers' productivity, growth decreases more as the minimum pension disappears.

Scenario 2: New educational distribution and dependency ratio. As in the case with the initial educational distribution and dependency ratio, we might firstly consider reductions in the minimum pension such that type-1 workers would still retire at the minimum retirement age and, accordingly, be paid the minimum pension (See table 3, columns 9 and 10) and, next, further reductions in $\hat{b}^{min}$ such that type-1 individuals would start retiring after the minimum legal retirement age, their pensions becoming earnings-related (See table 3, column 11). However, once we have thoroughly analyzed i) the specific effects induced by the change in educational distribution and dependency ratio, and ii) the effects stemming from the reduction on the minimum pensions (even its elimination) in the benchmark case, the arguments used to explain the results would be completely redundant, so they will not be repeated here.

Table 3
COMPARE STATICS RESULTS

Benchmark			Predicted *NBGP* (Secenario 1) $\Delta\hat{b}^{min}$ 0%	–10%	–15%	–100%	Predicted *NBGP* (Secenario 2) $\Delta\hat{b}^{min}$ 0%	–10%	–15%	–100%
R^1	60.6	R^1	63.0	63.0	63.0	64.6	63.0	63.0	63.0	65.2
R^2	64.7	R^2	65.2	65.2	65.2	65.2	65.8	65.8	65.8	65.8
R^3	64.8	R^3	65.4	65.4	65.4	65.4	65.9	65.9	65.9	65.9
R^4	65.0	R^4	65.5	65.5	65.5	65.5	66.1	66.1	66.1	66.1
$\hat{e}^1$	0.005	$\Delta\hat{e}^1$	2.84	2.89	2.92	16.98	17.83	17.87	17.88	37.11
$\hat{e}^2$	0.020	$\Delta\hat{e}^2$	–2.47	–2.42	–2.40	–2.74	14.31	14.34	14.36	13.97
$\hat{e}^3$	0.032	$\Delta\hat{e}^3$	–2.44	–2.39	–2.37	–2.70	14.34	14.38	14.40	14.01
$\hat{e}^4$	0.056	$\Delta\hat{e}^4$	–2.41	–2.36	–2.34	–2.66	14.38	14.41	14.43	14.05
irr^1	4.811	Δirr^1	–15.62	–24.50	–29.41	–71.64	–21.74	–30.78	–35.80	–71.51
irr^2	2.243	Δirr^2	–38.24	–38.25	–38.25	–38.26	–39.00	–39.00	–39.00	–38.97
irr^3	2.241	Δirr^3	–38.11	–38.12	–38.12	–38.11	–39.12	–39.12	–39.12	–39.09
irr^4	2.237	Δirr^4	–38.02	–38.02	–38.02	–38.00	–39.30	–39.31	–39.31	–39.26
λ_{annual}	0.02	$\Delta\lambda_{annual}$	–0.17	–0.17	–0.16	–0.19	0.96	0.96	0.96	0.94
I_G	0.25	ΔI_G	–1.33	–0.90	–0.68	–0.24	–12.42	–12.16	–12.02	–12.06
k	0.012	Δk	–1.53	–1.46	–1.42	–1.82	19.28	19.33	19.35	18.89
rest	0.008	$\Delta rest$	17.31	18.93	19.73	24.72	14.89	15.93	16.45	19.24

Δx: % change in x, where x stands for, $\hat{b}^{min}$, $\hat{e}^i$, λ, k, irr^i, and I_G. Columns 4-7 (resp. 8-11) show the results under the assumption that the distribution of the working-age population by education and the proportion of retirees with respect to the working-age population remain at their benchmark value in 2004 (resp. the expected for 2050).

4. Conclusions and final remarks

This paper has analyzed the expected effects of changes in the Spanish social security system that have been implemented after 2004 and, additionally, reductions in the minimum pension. We have built a two-period, OLG economy populated by ex-ante heterogeneous individuals, who differ in their innate ability and decide endogenously their retirement age and their human capital investment, which, in turn, will affect their productivity in the labor market. In this economy, endogenous growth is a by-product of most skilled workers' productivity. We take into account some of the specific features of the Spanish social security system such as that pension payments are earnings-related, that there is a minimum pension and that early retirement is penalized and late retirement promoted.

Given that pension payments are earnings-related, when individuals choose their optimal level of education, they take into account not only the effect on future labor earnings, but also on future pension benefits. Consequently, social security introduces an incentive for higher investment in human capital. This incentive, however, partly breaks down due to the minimum pensions. Individuals' second period labor supply is elastic. Therefore, the voluntary retirement age depends on the incentives embedded in the public pension system: not only minimum pensions, but also penalties for early retirement (and incentives for late retirement).

We have calibrated the model and constructed a benchmark case which fairly reproduces some stylized facts of the Spanish economy in 2004. Starting from this baseline case, firstly, we solve for a new balanced growth path economy taking into account social security policies which are currently in place in the Spanish economy or projected to be implemented in the near future (higher minimum and normal retirement ages). And, secondly, we analyze the effects of reductions in the minimum retirement pension benefits.

When presenting our results, we have distinguished partial equilibrium effects (those exerted on a *particular* type of individuals in a direct manner) from general equilibrium effects (those exerted on *all* individuals induced by changes in the social security surplus which, in turn, induces changes in aggregate private savings and factor prices).

We conclude that increases in the minimum and normal retirement ages, which have started to be implemented in 2011, are expected to have a strong effect, not only on individuals' retirement decisions, but also on their education investment in the resulting new balanced growth path. However, reductions in the minimum pension are not expected to have a significant effect unless it is completely eliminated. And, of course, policies enhancing human capital investment for the cleverest workers increase growth as a by-product of these workers' productivity.

Finally, one of the assumptions upon which we build our model is that all individuals enter the labor market at the same age, *i.e.* regardless of their educational attainment. This is so because education in our model is *not* made out of time. In that case, education would also represent an opportunity cost in which more skilled workers would be willing to incur more. In that setup one would expect that, as in our economy, more skilled workers making a higher educational investment would also react by postponing their retirement, without an *à priori* clear net effect on the working lives. The existing empirical evidence on the relationships between educational attainment, entry age into the labor market and retirement suggests positive relationships between the first two, and a negative relationship between educational level and the length of working lives. (See Brugiavini and Peracchi, 2005). We believe that our results are fairly robust to this assumption, because the predicted retirement age for more skilled individuals hardly exceeds that for less skilled individuals, except for type-1 individuals when they are paid the minimum pension.

5. Appendix A

5.1. Solution to households' problem

- **Optimal education and retirement pension.** If the pension benefit depends on the labor income that the individual obtained when he/she was a worker, the first order necessary condition comes from solving the following problem

$$\max_{\{e_t^i\}} NPV_1\left(e_t^i\right) = w_{n,t} h_t^i A_t + \frac{\Phi^i q^i \tau_{t+1}^{rep} w_t h_t^i A_t \ell_{t+1}^i}{R_{t+1}} + \frac{w_{n,t+1} h_t^i A_{t+1}\left(1 - \ell_{t+1}^i\right)}{R_{t+1}} - e_t^i .$$

Differentiating NPV_1 (e_t^i) with respect to e_t^i, taking into account Eq. (2), equating to 0 and solving that equation for e_t^i yields the solution for education expenditure[36]

$$e_{1,t}(\theta_i) \equiv A_t \left\{ \gamma\theta_i \left[w_t \left(1 - \tau_t^{ss} + \frac{\Phi^i q^i \tau_{t+1}^{rep} \ell_{t+1}^i}{R_{t+1}} \right) + \frac{w_{n,t+1}(1+\lambda_t)(1-\ell_{t+1}^i)}{R_{t+1}} \right] \right\}^{\frac{1}{1-\gamma}},$$

where $\lambda_t \equiv (A_{t+1} - A_t) / A_t$.

If the pension benefit does not depend on the labor income that the individual obtained when he/she was a worker, however, the first order necessary condition comes from solving the following problem

$$\max_{\{e_t^i\}} NPV_2(e_t^i) = w_{n,t} h_t^i A_t + \frac{w_{n,t+1} h_t^i A_{t+1}(1-\ell_{t+1}^i)}{R_{t+1}} - e_t^i .$$

Differentiating NPV_2 (e_t^i) with respect e_t^i to [again, taking into account Eq. (2)], equating to 0 and solving for the first-order-necessary (and sufficient) condition for e_t^i yields the solution for education expenditure

$$e_{2,t}(\theta_i) = A_t \left\{ \gamma\theta_i \left[w_{n,t} + \frac{w_{n,t+1}(1+\lambda_t)(1-\ell_{t+1}^i)}{R_{t+1}} \right] \right\}^{\frac{1}{1-\gamma}} .$$

- **The other optimal decisions: consumption, savings and leisure**. From Eqs. (3) and (4) we obtain the intertemporal budget constraint

$$\frac{ss_{t+1}}{R_{t+1}} + w_{n,t} h_t^i A_t + \frac{w_{n,t+1} h_t^i A_{t+1}(1-\ell_{t+1}^i)}{R_{t+1}} + \frac{b_{t+1}^i \ell_{t+1}^i}{R_{t+1}} = e_t^i + c_{y,t}^i + \frac{c_{o,t+1}^i}{R_{t+1}} . \qquad \text{[A.1]}$$

Maximizing Eq. (1) with respect to, $c_{y,t}^i$, $c_{o,t+1}^i$ and ℓ_{t+1}^i, subject to Eqs. (5), (6), (8) and (A.1), and using Eq. (3), yields the following system of non-linear equations which [along with Eq. (A.1)] characterize the optimal interior, $c_{y,t}^i$, $c_{o,t+1}^i$, ℓ_{t+1}^i and $s_{y,t}^i$:

$$\frac{1}{c_{y,t}^i} = \frac{\beta R_{t+1}}{c_{o,t+1}^i},$$

$$\frac{\xi c_{o,t+1}^i}{\ell_{t+1}^i} = w_{n,t+1} h_t^i A_{t+1} - b_{t+1}^i - \ell_{t+1}^i \frac{\partial b_{t+1}^i}{\partial \ell_{t+1}^i}, \; for \; \ell^L < \ell_{t+1}^i < \ell^U,$$

where

$$\frac{\partial b_{t+1}^i}{\partial \ell_{t+1}^i} = \begin{cases} 0, & if \;\; \ell^L < \ell_{t+1}^i < \ell^N \;\; or \;\; b_{t+1}^i = b_{t+1}^{\min} \\ \frac{-\alpha_1 b_{t+1}^i}{q^i}, & if \;\; \ell^N < \ell_{t+1}^i < \ell^U \;\; and \;\; b_{t+1}^{\min} < b_{t+1}^i \\ \frac{-\alpha_2 b_{t+1}^i}{\Phi^i}, & if \;\; \ell^L < \ell_{t+1}^i < \ell^N \;\; and \;\; b_{t+1}^{\min} < b_{t+1}^i \end{cases}$$

where h_t^i is given by Eq. (2).

5.2. Steady state competitive equilibrium

The steady state competitive equilibrium is characterized by the following equations. From Eq. (6) and the definition of $\underline{\theta}$, we obtain:

$$q^i \tau^{rep} w_n \underline{\theta} \left\{1 + \left[\hat{e}_1(\underline{\theta})\right]^{\gamma}\right\} = \hat{b}^{\min}(1+\lambda), \text{ and}$$
$$q^i = 1 - \alpha_1\left(\ell^i - \ell_N\right),$$

where $w_n \equiv (1 - \tau^{ss})w$.

From Eq. (17), we obtain $w = (1 - \alpha)Zk^a$ and $r + \delta = \alpha Zk^{\alpha-1}$

From Eqs. (2)-(19), we obtain

$$h^i = \theta_i\left[1 + (\hat{e}^i)^{\gamma}\right],$$
$$\hat{c}_y^i + \hat{s}_y^i + \hat{e}^i = w_n h^i,$$
$$\hat{c}_o^i = (1+r)\hat{s}_y^i + \ell^i \hat{b}^i(1+\lambda) + (1-\ell^i) w_n h^i (1+\lambda) + \widehat{ss},$$

$$\hat{e}_t^i = \begin{cases} \left\{\gamma\theta_i w_n\left[1 + \dfrac{(1+\lambda)(1-\ell^i)}{R}\right]\right\}^{\frac{1}{1-\gamma}}, \text{ for } \theta_i < \underline{\theta}, \\ \left\{\gamma\theta_i\left[w\left(1 - \tau^{ss} + \dfrac{\Phi^i q^i \tau^{rep} \ell^i}{R}\right) + \dfrac{w_n(1+\lambda)(1-\ell^i)}{R}\right]\right\}^{\frac{1}{1-\gamma}}, \text{ for } \theta_i \geq \underline{\theta}, \end{cases}$$

where $R = 1 + r$ and

$$\hat{b}^i = \begin{cases} \hat{b}^{\min}, \text{ for } \theta_i < \underline{\theta}, \\ \dfrac{\Phi^i q^i \tau^{rep} w h^i}{1+\lambda}, \text{ for } \theta_i \geq \underline{\theta}, \end{cases}$$

where

$$q^i = \begin{cases} 1, & \text{if } \ell^L \leq \ell^i \leq \ell^N, \\ 1 - \alpha_1\left(\ell^i - \ell^N\right), & \text{if } \ell^N \leq \ell^i \leq \ell^U, \end{cases}$$

and

$$\Phi^i = \begin{cases} 1, & \text{if } \ell^N \leq \ell_{t+1}^i \leq \ell^U, \\ 1 - \alpha_2\left(\ell^N - \ell_{t+1}^i\right), & \text{if } \ell^L \leq \ell_{t+1}^i \leq \ell^N, \end{cases}$$

$$\hat{c}_o^i = \beta R \hat{c}_y^i,$$

$$\xi \hat{c}_o^i = \ell^i w_n h^i (1+\lambda) - \ell^i \left[\hat{b}^i + \ell^i \frac{\partial \hat{b}^i}{\partial \ell^i} \right] (1+\lambda), \quad for \quad \ell^L < \ell^i < \ell^U,$$

where

$$q^i = \begin{cases} 0, & if \quad \ell^L < \ell^i < \ell^N \ or \ \hat{b}^i = \hat{b}^{\min} \\ \dfrac{-\alpha_1 \hat{b}^i}{q^i}, & if \quad \ell^N < \ell^i < \ell^U \ and \ \hat{b}^i > \hat{b}^{\min} \\ \dfrac{-\alpha_2 \hat{b}^i}{\Phi^i}, & if \quad \ell^L < \ell^i < \ell^N \ and \ \hat{b}^{\min} < \hat{b}^i \end{cases}$$

and

$$\sum_{i=1}^{4} \Psi_i \hat{s}_y^i = k(1+\lambda) \left[(1+n) \sum_{i=1}^{4} \Psi_i h^i + \sum_{i=1}^{4} \Psi_i h^i (1-\ell^i) \right],$$

$$\tau^{ss} w \left[(1+n) \sum_{i=1}^{4} \Psi_i h^i + \sum_{i=1}^{4} \Psi_i h^i (1-\ell^i) \right] = \sum_{i=1}^{4} \Psi_i \hat{b}^i \ell^i + \widehat{ss},$$

$$\lambda = \rho h^4$$

where

$$\hat{c}_y^i \equiv c_{y,t}^i / A_t, \hat{e}^i \equiv e_t^i / A_t, \hat{s}_y^i \equiv s_{y,t}^i / A_t, \hat{b}^{\min} \equiv b_t^{\min} / A_t, \hat{c}_o^i \equiv c_{o,t+1}^i / A_t, \hat{b}^i \equiv b_t^i / A_t,$$

$$\hat{s}s \equiv ss_{t+1} / A_t, A_{t+1} = (1+\lambda) A_t, P_{t+1} \equiv (1+n) P_t, \mu_o P_{t+1} \equiv \mu_y P_t, \ and \ k \equiv K_t / (L_t A_t).$$

Notes

1. See, *e.g.* Díaz-Giménez & Díaz-Saavedra (2009).
2. We assume that fertility and mortality are exogenous and that households are not altruistic. Thus, we do not follow the literature which assumes that parents care about the number of children and their well being and where parents invest in their children's human capital. (See, *e.g.*, Zhang & Zhang, 2004).
3. We could also consider the disincentive in human capital investment arising from the existence of a maximum retirement pension payment. However, we do not do so because the proportion of households affected by the maximum retirement pension hardly represents a 0.02% of retirement pensions in 2004, our benchmark year. See *Informe Estadístico 2004*, INSS, Ministerio de Trabajo y Asuntos Sociales, Cuadro 7.26, p. 244, for the distribution of retirement pensions in 2004, and *Seguridad Social, Presupuestos, Ejercicio 2011*, Anexo al Informe Económico-Financiero, Ministerio de Trabajo e Inmigración, Secretaría de Estado de la Seguridad Social, Cuadro II.2.3, p. 78, for the maximum retirement pension in 2004.
4. In this model one period represents 32.5 years. Assuming that individuals start their active life when they are 15 years old, the maximum amount of leisure depends on the minimum retirement age. For instance, in the U.S. it may be 0.77 (*i.e.* some individuals can retire at 55). See http://www.opm.gov/fers_election/fersh/h_fers3.htm for minimum retirement age (US Federal Employees Retirement Service).

5. Huggett et al. (2006), referring to the US economy, claim that "differences in learning ability account for the bulk of the variation in the present value of earnings across agents."
6. No distinction is made between "retirement age" and "pension age".
7. All individuals in their first period of life enter the labor market at the same time, *i.e.* regardless of the education expenditure made. Had we assumed a different time setting in our model, we could have assigned different ages for entering the labor market: thus, individuals attaining college education, for instance, would start working later than, say, those attaining primary school education. This point is left out in this paper.
8. Retirement pensions are *not* the only type of transfers that social security systems in real economies pay. For instance, Spanish social security also pays disability, widows', widowers' and orphans' pensions and family benefits, representing 66.45% of total pensions in 2000-2005. As an alternative, one might consider a unique consolidated budget for the social security and the government, so that tax rates were adjusted to keep the budget balanced. (See, *e.g.* Sánchez- Martín, 2005.)
9. Alternatively, one may assume that the retirement pension benefit does not depend on whether the individual is completely or partially retired, so that the pension payment is simply b^i_{t+1}. (See, *e.g.*, Garriga and Manresa, 1999.)
10. As pointed out above, we assume that there is not a legal maximum retirement pension benefit.
11. ℓ^i_{t+1} could be dropped from (5) because the utility function in (1) trivially prevents optimal ℓ^i_{t+1} from being zero.
12. A similar specification was used by Díaz-Giménez and Díaz-Saavedra (2009a,b).
13. For the sake of emphasizing the economic intuition of the solutions, we break this problem into two separate cases, depending on whether pension benefits are earnings-related or not.
14. The solution to the households' problem is obtained in the Appendix A to which the reader is referred for further detail.
15. Notice the notation: $e_{1,t}(\theta_i)$ denotes the education chosen at time t by an individual of skill level θ_i *whose retirement pension benefit is earnings related.*
16. Education expenditure increases with learning ability, since the individual labor productivity is an increasing function of the individual's learning ability.
17. In a narrow sense, as in Romer (1990).
18. In particular, we have used Matlab©.
19. *INE* stands for *Instituto Nacional de Estadística* (Spanish National Institute of Statistics), which can be accessed at *http://www.ine.es*
20. More precisely, n has been calculated such that for a deterministic life expectancy at birth of 80, a normal retirement age of 65 and a dependency ratio of 0.25 in 2004 (and under the assumption that one period in this economy represents 32.5 years), it holds that $((80-65)/32.5)/(1+n+(65-47.5)/32.5) = 0.25$.
21. As pointed out elsewhere, a discount factor higher than one (*i.e.* a negative time preference rate) is not a problem in OLG economies. (See Ventura, 1999, and Constantinides et al., 2002.)
22. Since 2002, the minimum retirement age is set to 61 years for all workers that entered the labor market after 1967. Consequently, most workers retiring in 2004 were in the labor market *before* 1967, so that they could still retire at 60. (See Díaz-Giménez and Díaz-Saavedra, 2009b, and *LEY 35/2002*, Boletín Oficial del Estado No. 167, July 13, 2002, p. 25633).
23. These figures have also been obtained from the *Encuesta de Estructura Salarial* (Wage Structure Survey)*, 2002, INE.* The *Encuesta de Estructura Salarial* is only available in 1995 and 2002. We have chosen 2002 since it is the closest year.
24. Since in 2004, 27.84% of General Regime pensioners were receiving the minimum pension, we set $\psi_1 = 0.2784$.

25. In this model, this value does not play an important role as we are not building a concave life-cycle labor income pattern.

26. In Spain in 2004, the minimum retirement pension oscillated between 84.70% and 114.09% of the minimum wage, depending on whether the retiree i) was below 65 or not, and ii) had a dependent spouse or not; additionally, a legal reform was introduced mid-year. See Seguridad Social, Presupuestos, Ejercicio 2011, Anexo al Informe Económico-Financiero, Ministerio de Trabajo e Inmigración, Secretaría de Estado de la Seguridad Social, Cuadro II.4.3, p. 85.

27. See *Bases y Tipos de Cotización 2006* at *http://www.seg-social.es.* This has been the contribution rate for *Régimen General y Regímenes Especiales Asimilados* (General Regime and Assimilated Special Regimes) since 1995. It is split between employers (23.6%) and employees (4.7%). Special regimes include: the self-employed, agriculture workers and "home employees". Special regimes exclude: sea workers and coal miners. See *Anexo al Informe Económico Financiero a los Presupuestos de la Seguridad Social de 2005. Capítulo I. Cotización a la Seguridad Social, Cuadro 3*, without page number.

28. Along balanced growth paths, the replacement rate for type-1 retirees is given by $\hat{b}^{min}(1+\lambda)/(wh)$, and that of type-2, type-3 and type-4 is equal to $q\tau^{rep}$. The incentives to late retirement were not included up to the 2008 reform through LEY 40/2007 de medidas en materia de Seguridad Social, BOE No. 291, December 5, 2007, p. 50190. That reform set a 2% bonus for each additional year after 65 to all contributory affiliates, and a 3% bonus if the affiliate had contributed for more than 40 years.

29. See *OECD* (2005), p. 172.

30. Díaz-Giménez and Díaz-Saavedra (2009) mention that the Gini income inequality in Spain in 1997 is 0.39.

31. Jiménez-Martín & Sánchez (2007) show that the minimum pension was very similar to the legislated minimum wage in Spain in 2000. However, in our model, we force the minimum pension close to the average wage received by the least educated individuals.

32. See *Encuesta de Estructura Salarial 2002*, p. 3, Instituto Nacional de Estadística.

33. In none of the proposed reforms changes in the pay-roll tax rate have been considered.

34. As pointed out in footnote 28, the increment in the late retirement age stimulus was implemented in the 2008 reform. Regarding the delay in the normal retirement age, the increase in the minimum retirement age (fully effective in 2027) and the 3% bonus, these changes are part of the projected social security reform for 2011. See *Anteproyecto de Ley de Reforma de la Seguridad Social* at http://www.lamoncloa.gob.es/ConsejodeMinistros/Referencias/2011/refc20110128.htm

35. As suggested by one of the referees, we also run the experiment of considering *no changes* in minimum legal retirement age, the normal retirement age and the bonus for late retirement, *but* introducing minimum pension reductions, as a means to isolate the specific effects induced changes $\hat{b}^{min}$ in alone. It can be shown that, in that case, the partial effect on type-1 individuals would have been of higher magnitude than the general effect coming from the increase in the surplus, and the new equilibrium k would *increase* rather than decrease.

36. The first necessary condition is also sufficient as $NPV_1(e_t^i)$ is concave in e_t^i.

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Resumen

Este trabajo analiza, en primer lugar, los efectos esperados de las reformas de la seguridad social que se han llevado a cabo en España después de 2004 (y, en segundo lugar, los efectos esperados de la reducción de la pensión mínima) en la decisión de retiro y en la acumulación de capital humano (y por lo tanto en el crecimiento y en la desigualdad de ingresos). Los individuos de nuestra economía difieren en su capacidad innata, y el crecimiento es un subproducto de la productividad de los individuos más cualificados. Según nuestro modelo, *i*) se espera que los aumentos de las edades de jubilación mínima y normal tengan un fuerte efecto no sólo sobre las decisiones de jubilación, sino también sobre las de inversión en educación, *ii*) no se espera que los incentivos al retraso de la jubilación tengan ningún efecto, y *iii*) no se espera que la reducción de la pensión mínima tenga un efecto significativo a menos que se elimine por completo.

Palabras clave: Seguridad Social; Sistema de Reparto; Retiro Voluntario; Capital Humano; Pensión Mínima.

Clasificación JEL: O4, H3