Delaying Retirement in Spain*

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Abstract

We study the reform of the Spanish public pension system in an overlapping generations model economy populated by households who differ in their education, receive a stochastic endowment of efficiency labor units, and face disability and survival risks. The households understand the link between the payroll taxes that they pay and the public pensions that they receive, and they decide how much to consume and to work and when to retire from the labor force. We calibrate this economy to Spanish data so that it replicates its fiscal policy instruments, its macroeconomic aggregates and ratios, and the Lorenz curves of its income and earnings distributions in 1997. We use the model economy to study the aggregate, distributional and welfare consequences of delaying the first retirement age from 60 to 63 years and the normal retirement age from 65 to 68 years in the year 2010. We find this reform makes the Spanish public pension system sustainable until the year 2061 and that it improves social welfare from the year 2021 onwards.

Keywords: Computable General Equilibrium, Social Security Reform, Retirement

JEL Classification: C68, H55, J26

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1 Introduction

The financial viability of pay-as-you-go pension systems is being questioned for two main reasons: the aging of the populations and the tendency of workers to retire at younger ages. Consequently, in the next few decades, the retiree to worker ratios of developed economies will increase substantially, and most of the current unfunded pension systems will no longer be financially viable. Another trend that affects the financial situation of unfunded pensions systems is the tendency of workers to become more educated. This educational transition is important because more educated workers pay higher payroll taxes during their working lives and they collect higher pensions when they retire. The purpose of this article is to study the aggregate, distributional, and welfare consequences of reforming the Spanish public pension system when we endogenize the retirement decision and we take into account both the demographic and the educational transitions, which are particularly severe in the Spanish case.

The Spanish demographic transition. In 1997 in Spain there were 23 retirees for every hundred working-age people. According to the projections of the Spanish *Instituto Nacional de Estadística*, by the year 2050 this number will have increased to no less than 56. This change is due to the increase in life-expectancy and to a substantial reduction in Spanish birth-rates. Between 1957 and 1977 the average number of children per fertile woman was 2.8. Since 1980 this number has decreased continuously, and in 1998 it was only 1.16. As we show in this article, these demographic changes make the current pay-as-you-go Spanish public pension system completely unsustainable.

The Spanish educational transition. In 1977 in Spain only about nine percent of the working-age people had completed high school and only about three percent had completed college. Twenty years later, these shares were 24 percent and 13 percent. By the year 2050 they are projected to be 38 percent and 24 percent (see Meseguer, 2001). This educational transition has important implications for the sustainability of the Spanish pay-as-you-go pension system (see Díaz-Giménez and Díaz-Saavedra (2006a) for a quantitative analysis of this issue).

Early retirement in Spain. According to Conde-Ruiz and Galasso (2003) the participation rate of Spanish male workers in the 55-64 age cohort was 84.2 in 1970 and by the year 2000 this rate had fallen by to only 60.3. Part of this substantial decline was due to a reduction of the average retirement age of almost four years during the same period (from 65.2 years in 1970 to 61.4 in 1995 according to Blöndal and Scarpetta, 1997). This trend increases the retiree to worker ratios even further and places an additional burden on the Spanish unfunded public pension system.

The Model Economy. We study this reform in an overlapping generations model economy that combines various features of similar models described elsewhere in the literature. First, our model economy is populated by natives and immigrants as in Rojas (2005). This feature is important because in the last few years Spain has received large flows of immigrants that are projected to continue in the future, and these flows have important consequences for the sustainability of the Spanish public pension system (see Díaz-Giménez and Díaz-Saavedra, 2006b). Second, our households differ in their education levels as in Cubeddu (1998). This feature allows us to model the Spanish educational transition and to study its consequences for the sustainability of the pension system. It is also important because early retirement behavior is strongly influenced by educational attainment. Third, our households face stochastic lifetimes as in Hubbard and Judd (1987). This feature allows us to model the longevity insurance role of pension systems and the significant increase in life-expectancy projected for the Spanish economy. Fourth, our households face an uninsurable idiosyncratic shock to their endowments of efficiency labor units as in Conesa and Krueger (1999). This feature allows us to account for the income and earnings distributions of the Spanish economy and for the participation rates and the retirement ages of Spanish elderly workers. Fifth, our households face the possibility of becoming disabled and receiving a disability pension. Rust and Phelan (1997) introduce this feature in a partial equilibrium model. We model this feature because disability pensions are an alternative route to early retirement in Spain (see Boldrin and Jiménez-Martín (2003) for an elaboration on this argument). Sixth, our households take into account the link between payroll taxes and pensions when making their consumption, savings and retirement decisions as in Huggett and Ventura (1999). We model this feature because pension entitlements are a sizable part of the compensation of workers and they play an important role in the labor decision, specially towards the end of the workers' lives. Finally, our households decide optimally when to retire as in Sánchez-Martín (2003). This feature endogenizes the number of workers and allows us to account for the tendency of Spanish workers to opt for early retirement.

We also model the institutional features of the current Spanish public pension system in very much detail. Our model economy pensions replicate the Spanish payroll tax cap, the maximum covered earnings, the minimum and maximum pensions, the pension replacement rate, the penalties for early retirement, the pension fund and the disability pensions. In addition, the government in our model economy taxes labor income, capital income and consumption, it spends in public consumption and transfers other than pensions, and it services a stock of public debt. Other important features of our model economy are that it replicates replicates the Lorenz curves of the Spanish earnings and income distributions as reported in Budría and Díaz-Giménez (2006), and that it accounts for many of the main features of the retirement behavior of Spanish workers.

Findings. The reform that we study delays the first retirement age from 60 to 63 years and the normal retirement age from 65 to 68 years. We assume that this reform is implemented in the year 2010, and that it affects all current workers and disabled households. We find that delaying by three years the first and the normal retirement ages is sufficient to solve the severe viability problems that plague the current Spanish pension system, which we have analyzed elsewhere (see Díaz-Giménez and Díaz-Saavedra, 2006a). According to our estimates, in the year 2060, under the current rules, the debt of the Spanish pension system fund would be approximately equal to two GDP's. In contrast, if the retirement ages were to be delayed by three years starting in 2010, in the year 2060 the pension system fund would be 1.1 percent of output in the black. We also find that the proposed reform is moderately expansionary (it increases the average yearly growth rate of output by 0.06 percent) and that it increases income inequality somewhat: in 2060 the Gini index of income is 0.411 in the reformed economy and 0.403 under the current rules.

Finally, if we allow the government to issue debt to finance the pension deficits indefinitely, we find that the reform brings about an aggregate welfare loss between 2010 and 2060 that is equivalent to approximately 3.30 percent of the present value of aggregate consumption in the benchmark model economy during that period. In contrast, delaying retirement in a model economy where consumption taxes have to be raised to pay for the pension system deficits once the pension fund is exhausted brings about a social welfare gain which is equivalent to 0.57 percent of the present value of aggregate consumption.

Conclusions. We conclude that policymakers should seriously consider reforming the Spanish public pension system along these lines sometime in the near future.

2 Previous literature

The study of parametric reforms of pay-as-you-go pension systems threatened by sizeable demographic transitions has been subject of a large body of previous research. In a general equilibrium setup, De Nardi, İmrohoroğlu, and Sargent (1999), for instance, study the consequences for the U.S. economy of increasing the compulsory retirement age in two years. They find that this reform reduces the size of the fiscal burden, and that the consumption tax rate used to finance this burden falls from 36.9 to 31.2 percent.

Amongst the general equilibrium studies of pension reforms in Spain, the article that is closest to ours is Sánchez-Martín (2003). He also uses a general equilibrium, multiperiod overlapping generations model of households who differ in their education. He finds that delaying in two years the normal retirement age, reduces the pension system deficit in 2060 from 6.9 to 4.3 percent of GDP. The main differences between Sánchez-Martín's article and ours are that he abstracts from the educational transition and from the pension fund and that he uses lump-sum taxes to balance the government budget.[1]

De Miguel and Montero (2004) also study a general equilibrium multiperiod overlapping generations model economy populated by homogeneous households who face a survival risk. They simulate a reform that delays the normal retirement age from 65 to 70. They find that the pension payments to output ratio decreases from 13.2 to 9.5 percent by the year 2050 and that the labor income tax rate that is needed to finance the pension system falls from 19.2 to 13.9 percent in that same year.[2]

Most of the studies of pension reforms in Spain have been either partial equilibrium analyses or accounting models. The findings of these modeling approaches are summarized in Jimeno, Rojas, and Puente (2006). Amongst these studies, Boldrin and Jiménez-Martín (2003) find that delaying in 3 years the first and the normal retirement ages makes most of the people who now retire at 65 delay their retirement until 68, and that it brings about substantial increases in the labor force participation of the elderly. Even though their model economy does not simulate the evolution of the pension system deficit, they conclude that this reform would not be enough to sustain the Spanish public pension system during the next few decades, but this is mainly because they abstract from the pension system fund.

Da Rocha and Lores (2005) use an individual life profile approach to study the consequences of delaying the normal retirement age in five years. They implement the reform in 2005, and they find that the accumulated value of the debt in 2050 is reduced from 259 percent of GDP in their benchmark economy to 59 percent of GDP in their reformed economy. The differences between their results and ours arise mainly because the ratio of pension expenditures to GDP is 25.5 percent in the year 2050 in their model economy. In our model economy and in many of the other articles referenced here this number is approximately 17.5 percent.

Finally, Balmaseda, Melguizo and Taguas (2006) study the consequences for the viability of the Spanish Public Pension System of increasing the compulsory retirement age from 65 to 70 under different scenarios about the Spanish demographics and about the Spanish labor market. They use a general accounting approach with no endogenous responses to the policy changes, and in their more optimistic demographic scenario, they find that this reform reduces the present value of the accumulated pension system debt accumulated until 2050 from 182 percent of 2004's GDP to 9.6 percent, and that the reform delays in 28 years the depletion of the pension fund (from 2018 in their benchmark model economy to 2046 in their reformed economy).

[1] Sánchez-Martín (2003) also abstracts from maximum pensions, disability pensions, and the pension replacement rate, and his payroll tax is uncapped.

[2] Arjona (2000) studies a very similar model economy. The main differences between these two articles are the way they model the demographic transition and the policy reforms that they analyze.

Table 1: Payroll taxes and Pensions in Spain and in our Model Economy*

Payroll Taxes		
	Spain	Model Economy
Tax Rate	Proportional	Proportional
Maximum Cap	Yes	Yes
Tax Exempt Minimum	Yes	No
Pensions		
	Spain	Model Economy
Regulatory Base	Last 15 years prior to retirement	Last 15 years prior to retirement
Replacement Rate	Dependent on the years of contributions	Independent of the years of contributions
Maximum covered earnings	Yes	Yes
Maximum pension	Yes	Yes
Minimum pension	Yes	Yes
Early retirement penalties	Yes	Yes
Pension fund	Yes	Yes
Disability pension	Yes	Yes

*The rules that describe the Spanish public pension system are those of the *Régimen General de la Seguridad Social*

3 The model economy

We study an overlapping generations model economy. We assume that the model economy period corresponds to one year and that total factor productivity grows at an exogenous rate, γ. We also model the growth rate of the population which is partly endogenous. In our model economy there are two sectors, a public sector and a private sector, which we model as follows:

3.1 The public sector

The public sector of this model economy runs a pay-as-you-go public pension system, it collects income and consumption taxes, and it uses their revenues to finance flows of government consumption and of transfers other than pensions, and to service a stock of public debt.

3.1.1 The public pension system

In Table 1 we describe the main features of the Spanish and the model economy's public pension systems which are the following:

Payroll taxes. The Spanish pension system is financed with a capped payroll tax on gross labor earnings with a tax-exempt minimum. In our model economy this payroll tax is described by function, $\tau_s(y_t)$, where y_t denotes gross labor earnings at period t. Our chosen functional form allows us to replicate the payroll cap but it does not allow us to model the tax exempt minimum (see Panel A of Figure 2).

Retirement pensions. A retiree of age j is entitled to receive a public pension, b_t, while he is alive. As in the Spanish pension system, we assume that this pension is bounded by a minimum pension, $\underline{b}_t$, and by a maximum pension, $\overline{b}_t$. We allow these limits to vary with time because we are studying a growth economy and in Spain minimum and maximum pensions are adjusted to keep up with output. The government also determines the first retirement age, R_0, and the normal retirement age, R_1.

To capture the main features of Spanish pensions, we assume that the pensions in our model economy are computed according to the following formula:

$$b = \frac{1}{N_b}(1-\lambda_j)\phi \sum_{t=j-N_b}^{j-1} \min\{a_{0t}, y_t\} \tag{1}$$

where $0 \leq \lambda_j < 1$ is the penalty for early retirement, $0 < \phi < 1$ is the pension system replacement rate, N_b is the number of consecutive years immediately before retirement that are used to compute the pension, and a_{0t} is the maximum covered earnings. Finally, the pension claims of workers who choose to keep working after they reach the normal retirement age, R_1, increase by 2 percent per year.[3]

Disability pensions. To replicate the Spanish disability pensions, we assume that the public pension system in our model economy pays a pension to disabled households, b_{dt}. As is the case in Spain, we assume that the disability pensions are 75 percent of the household's retirement claim and that there is a minimum disability pension which is equal to the minimum retirement pension. Consequently, $b_{dt} = \max\{\underline{b}_t, 0.75b\}$.

The pension system fund. In Spain in 2000 the government created a pension system fund to capitalize the pension system surpluses. To replicate this feature in our model economy, we assume that from 2005 onwards the government moves the pensions and the payroll tax revenues off-budget and that it operates a pension system fund, F_t. We assume that this fund is invested in foreign assets, and that these assets obtain an exogenous rate of return, r^*. We make this assumption to buffer the model economy from the large distortions created by the sizable public pension deficits that are predicted to take place during the Spanish demographic and educational transitions. The fund works as follows: whenever there is a surplus in the pension system, it is invested in the fund, and whenever the public pension system goes into a deficit, the fund assets are used to finance the deficit until they are exhausted. After the

[3]This feature of the pension rules was introduced in the 2002 Amendment of the Spanish Public Pension System.

fund assets are exhausted, we assume that the government borrows as much as necessary to finance any further pension system deficits at the same exogenous rate r^*. Therefore, the law of motion of the pension fund is the following:

$$F_{t+1} = (1 + r^*)F_t + T_{st} - P_t \tag{2}$$

where T_{st} denotes the revenues collected by the payroll tax and P_t denotes the aggregate retirement and disability pensions.

3.1.2 The government budget

We report the main revenue and expenditure items of the Spanish government in Table 2. Our choices for the tax instruments and the expenditure items of the model economy public sector are made to replicate as closely as possible the items in this table.

Revenues. The government collects tax revenues using a proportional tax on capital income, τ_{kt}, a proportional tax on labor income net of payroll taxes, τ_{lt}, and a proportional consumption tax, τ_{ct}. The government confiscates unintentional bequests, E_t and it issues one period real debt, D_{t+1}.

Outlays. The government in our model economy spends an exogenous amount, G_t, it makes exogenous lump-sum transfers to households other than pensions, Z_t, and it repays the principal plus the interest on an endogenous stock of public debt, $(1 + r_t)D_t$, where r_t is the equilibrium interest rate which we define below.

Budget constraint. Until 2005 the government budget constraint is

$$G_t + Z_t + (1 + r_t)D_t + P_t = T_{kt} + T_{lt} + T_{ct} + E_t + D_{t+1} + T_{st} \tag{3}$$

where T_{kt}, T_{lt}, and T_{ct} denote the revenues collected by the capital income tax, the labor income tax, and the consumption tax.

After 2005, when the pension fund starts to operate and the payroll tax revenues and the pension payments are moved off-budget, the government budget described in expression (3) becomes

$$G_t + Z_t + (1 + r_t)D_t = T_{kt} + T_{lt} + T_{ct} + E_t + D_{t+1} \tag{4}$$

3.2 Firms

We assume that the firms in our economy behave competitively in the product and factor markets, that they maximize profits, and that they have free access to a production technology that can be described by a constant returns to scale aggregate production function, $Y_t = F(K_t, A_t L_t)$, where Y_t denotes aggregate output, K_t denotes aggregate capital and L_t denotes the aggregate labor input. Variable A_t denotes an exogenous, labor-augmenting productivity factor whose law of motion is $A_{t+1} = (1+\gamma)A_t$, where $\gamma > 0$. We assume that the capital stock depreciates geometrically at a constant rate, $0 < \delta < 1$, and we use r and w to denote the rates of return to capital and labor, gross of all taxes.

The profit maximizing behavior of firms implies that factor prices are the corresponding factor marginal productivities

$$r_t = F_K(K_t, A_t L_t) - \delta \tag{5}$$

$$w_t = F_L(K_t, A_t L_t) \tag{6}$$

Notice that in our model economy labor productivity grows for two reasons: first, because $\gamma > 0$ and, second, because as workers become more educated they also become more productive.

3.3 Households

Population dynamics. We assume that our model economy is inhabited by continuum of heterogeneous households, which we normalize each period so that its measure is always equal to one. The households differ in their birth place, $\ell \in \mathcal{L}$, in their age, $j \in J = \{20, 21, \ldots, \mathcal{J}\}$, in their education levels, $h \in H$, in their employment status, $s \in S$, in their assets, $a \in A$, and in their pension claims, $b \in B$. Let $\mu_t(\ell, j, h, s, a, b)$ be the measure of households of type (ℓ, j, h, s, a, b). For convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript. For instance, $\mu_t(j, h) \equiv \mu_t(\cdot, j, h, \cdot, \cdot, \cdot)$ denotes the period t measure of all households of age j and education level h.

Households can either be native to the economy, and then $\ell = n$, or they can be immigrants, and then $\ell = i$. We assume that a measure $\mu_t(i, j, h, s, a, b)$ of immigrants enters the economy at the beginning of each period, and that this measure is exogenous. Each period both immigrants and natives face a conditional probability of surviving from age j to age $j+1$, which we denote by $\psi_t(j)$. They also face an age dependent probability of having offspring, which we denote by $f_t(j)$.[4] Finally, we assume that the offspring of immigrants are natives, and that the youngest immigrants and the offspring enter the economy at age $j = 20$.

These assumptions imply that at the beginning of every period there is a measure $1 + n_t$ of households in our economy. Variable n_t denotes the population growth rate, which we compute

[4] We assume that immigrants and natives have the same survival probabilities and fertility rates because independent data for these two population groups are not readily available.

as follows:

$$n_t = \mu_t(i) + \sum_J \left[\psi_{t-1}(j) + f_{t-1}(j)\right] \mu_{t-1}(j) - 1. \tag{7}$$

We then renormalize the measures of households so that the law of motion of $\mu_t(j)$ is

$$\mu_{t+1}(20) = \frac{1}{(1+n_t)} \left[\mu_{t+1}(i, 20) + \sum_J f_t(j)\mu_t(j)\right] \tag{8}$$

and

$$\mu_{t+1}(j) = \frac{1}{(1+n_t)} \left[\mu_{t+1}(i, j) + \psi_t(j-1)\mu_t(j-1)\right] \tag{9}$$

for each $j > 20$.

Education. In this article we abstract from the education decision and we assume that the education level of both natives and immigrants is fixed for ever when they enter the economy. We also assume that there are three educational levels, $h \in H = \{1, 2, 3\}$. Educational level $h = 1$ denotes that the household has not completed high school.[5] Educational level $h = 2$ denotes that the household has completed high school but has not completed college. Finally, educational level $h=3$ denotes that the household has completed college.

Employment status. Households in our economy are either workers, disabled or retired. We denote workers by $s \in \mathcal{S} = \{s_1, s_1, \ldots, s_n\}$ disabled households by d, and retirees by ρ. Each period, every worker receives an endowment of efficiency labor units. This endowment has two components: a deterministic component that depends on the age and the education of the worker, $\epsilon(j, h)$, and a stochastic idiosyncratic component, s. The process on the stochastic component follows a finite state Markov chain that is independent and identically distributed across workers, and whose conditional transition probability matrix is $\Gamma_{ss'} = Pr\{s_{t+1} = s' | s_t = s\}$, where s and $s' \in \mathcal{S}$. We assume that workers also face an age and education-dependent disability risk. Specifically, a worker of type (j, h) faces a probability $\varphi(j, h)$ of being disabled from age $j+1$ onwards.[6] We also assume that workers who are R_0 years old or older observe the realization of their shock and they decide whether or not to retire form the labor force. Finally we assume that both disabled households and retirees receive no endowments of efficiency labor units. All these assumptions imply that the set of realizations of the household specific shock is $S = \{\mathcal{S}, d, \rho\} = \{s_1, s_1, \ldots, s_n, d, \rho\}$

Preferences. We assume that the households in our model economy have identical preferences

[5] In this group we include every household that has not completed the compulsory education. Due to the changes in the Spanish educational laws, we define the compulsory studies to be either the *Estudios Secundarios Obligatorios*, the *Graduado Escolar*, the *Certificado Escolar*, or the *Bachiller Elemental.*

[6] We model disability explicitly because in many cases disability pensions are another route to early retirement. This point is made in Boldrin and Jiménez-Martín (2003).

that can be described by the following expected utility function:

$$E\left[\sum_{j=20}^{\mathcal{J}} \beta^{j-20}\psi(j)u(c_j, 1-l_j)\right] \tag{10}$$

where the function u is continuous and strictly concave in both arguments, $\mathcal{J}$ is the maximum age, $0 < \beta$ is the time discount factor, c_j is consumption and l_j is labor. Consequently, $1 - l_j$ is the amount of time that the households allocate to non-market activities.

The households' decision problem

The households in our model economy solve the following decision problem:

$$\max E\left\{\sum_{j=20}^{\mathcal{J}} \beta^{j-20}\, \psi_t(j)\, u(c_{j,t+j-20}, 1-l_{j,t+j-20})\right\} \tag{11}$$

subject to

$$c_{jt} + a_{jt+1} + \tau_{jt} = (1+r_t)\, a_{jt} + z_t + w_t\, \epsilon_j\, s_t\, l_{jt}\, I_{s\in\mathcal{S}} + (1-\lambda_j)\, b_t\, I_{s'=\rho} + b_{dt}\, I_{s=d} \tag{12}$$

and to

$$\tau_{jt} = \tau_{ct}\, c_{jt} + \tau_{kt}\, r_t\, a_{jt} + \tau_{lt}[y_{jt} - \tau_{st}(y_{jt})\, I_{j\leq R_1}] + \tau_{st}(y_{jt})\, I_{j\leq R_1} \tag{13}$$

In these two expressions a_{jt+1} denotes the end-of-period assets, z_t denotes the government transfers, y_{jt} denotes the labor income which is equal to $y_{jt} = w_t\, \epsilon_j\, s_t\, l_{jt}$, and the indicator functions $I_{s\in\mathcal{S}}$, $I_{s'=\rho}$, $I_{s=d}$, and $I_{j\leq R_1}$, indicate whether the household is a worker, retired, or disabled, and whether it was R_1 years old or less after year 2001.[7] Finally, the rules to compute the retirement pension, b_t, are described in expression (1) and the early retirement penalties, λ_j, are described in expression (24).

When the households are between 20 and (R_0−1) years old, they cannot retire and they decide how much to consume, to save and to work taking into account how these decisions affect their future pension claims. When workers reach age R_0 they also decide whether or not to retire. When disabled households reach age R_0, they decide whether to collect the disability pension or the retirement pension. Finally, when workers reach age 84 they are forced to retire.

To gain some intuition about the trade-offs involved in the retirement decision, let us consider the benefits and costs of continuing to work after age R_0. The benefits are the wages earned and the avoidance of the early retirement penalties. The costs are the forgone leisure and

[7] In 2002 the Spanish public pension system was amended and workers older than R_1 years were exempted from paying payroll taxes. We use indicator function $I_{j\leq R_1}$ to replicate this feature of the Spanish pension system.

the foregone pension. But there is also another effect: the change in the pension claim, $(b_{t+1} - b_t)$. This change could be either a benefit or a cost, depending on the household's current endowment of efficiency labor units, $\epsilon_j s_t$, and on its pension entitlement, b_t. Minimum retirement pensions also play an important role in the retirement decision. Since every retiree is entitled to receive the minimum retirement pension, it eliminates the incentive to avoid the early retirement penalties for workers whose pension claim is sufficiently smaller than $\underline{b}$. Consequently, these households choose to retire at the first retirement age, R_0.

3.4 Market arrangements

We assume that there are no insurance markets for the household-specific shock. This is a key feature of this class of model worlds. When insurance markets are allowed to operate, every household of the same birthplace, age and education level is alike and the income and wealth distributions in our model economy become much more disperse. We also assume that the households in our model economy cannot borrow. Since leisure is an argument of the households' utility function, this borrowing constraint can be interpreted as a solvency constraint that prevents the households from going bankrupt in every state of the world. These restrictions give the households a precautionary motive to save. They do so accumulating real capital, a_t, which belongs to a compact set $\mathcal{A}$.[8] Finally, we assume that firms rent factors of production from households in competitive spot markets. This assumption implies that factor prices are the corresponding factor marginal productivities.

Definition of equilibrium

Let $\ell \in \mathcal{L} = \{i, n\}$, $j \in J = \{20, 21, ..., \mathcal{J}\}$, $h \in H = \{1, 2, 3\}$, $s \in S$, $a \in \mathcal{A}$, and $b \in B = [\underline{b}_t, \overline{b}_t]$, and let $\mu_t(\ell, j, h, s, a, b)$ be a probability measure defined on $\Re = \mathcal{L} \times J \times H \times S \times \mathcal{A} \times \mathcal{B}$.[9] Then, given initial conditions μ_0, D_0, E_0, F_0, and K_0, a competitive equilibrium for this economy is a government policy, $\{G_t, Z_t, T_t, E_{t+1}, D_{t+1}, F_{t+1}, T_{st}, P_t\}_{t=0}^{\infty}$, a household policy, $\{c_t(j, h, s, a, b),\ l_t(j, h, s, a, b),\ a_{t+1}(j, h, s, a, b)\}_{t=0}^{\infty}$, a sequence of measures, $\{\mu_t\}_{t=0}^{\infty}$, a vector of factor prices, $\{r_t, w_t\}_{t=0}^{\infty}$, a vector of macroeconomic aggregates, $\{K_{t+1}, L_t\}_{t=0}^{\infty}$, a function, Q, and a number, r^*, such that the following conditions hold:

(i) Factor inputs, tax revenues, pension payments, transfers, and accidental bequests are

[8] In overlapping generation models with finite lives and no altruism there is no need to impose such upper bound for set A since households who reach the maximum age will optimally consume all their assets. İmrohoroğlu, İmrohoroğlu, and Joines (1995) make a similar point.

[9] Recall that, for convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript. For instance, $\mu_t(j, h) = \mu_t(\cdot, j, h, \cdot, \cdot, \cdot, \cdot)$ denotes the period t measure of households of age j and education level h. We also drop the first subscript whenever there are no differences between immigrants and natives.

obtained aggregating over the model economy households as follows:

$$(K_{t+1}+D_{t+1}) = \int a_{t+1} d\mu_t \tag{14}$$

$$\begin{aligned}
L_t &= \int \epsilon s_t l_t d\mu_t && (15)\\
T_{st} &= \int \tau_{st}(y_t)\, I_{j\leq R_1}\, d\mu_t && (16)\\
T_t &= \int \{\tau_{ct}c_t + \tau_{kt}r_t a_t + \tau_{lt}\left[y_t - \tau_{st}(y_t)\, I_{j\leq R_1}\right]\}\, d\mu_t && (17)\\
P_t &= \int (b_t + b_{dt}) d\mu_t && (18)\\
Z_t &= \int z_t d\mu_t && (19)\\
E_{t+1} &= \int (1-\psi_t(j))(1+r_t)a'_t d\mu_t && (20)
\end{aligned}$$

where $y_t = w_t\, \epsilon\, s_t\, l_t$ and all the integrals are defined over the state space $\Re$.

(ii) The government policy satisfies the law of motion of the pension system fund described in expression (2) and the government budget constraints described in expressions (3) and (4).

(iii) Given, K_t, L_t, and the government policy, factor prices are the factor marginal productivities defined in expressions (5) and (6), and the household policy solves the households' decision problem defined in expressions (11), (12) and (13).

(iv) The goods market clears:

$$\int_{\Re} c_t d\mu_t + K_{t+1} + G_t + (T_{st} - P_t) = F(K_t, A_t L_t) + (1-\delta)K_t. \tag{21}$$

(v) The law of motion for μ_t is:

$$\mu_{t+1} = \int_{\Re} Q_t d\mu_t. \tag{22}$$

Describing function Q formally is complicated because it specifies the transitions of the measure of households along its six dimensions: place of birth, ℓ, age, j, education level, h, employment status, s, asset holdings, a and pension entitlement, b. An informal description of this function is the following: since the flows of immigrants are exogenous to the model economy, the evolution of ℓ is exogenously given. The evolution j is described in expressions (7), (8) and (9). The evolution of h is implied by the educational shares of immigrants and native new-entrants, both of which are given exogenously. The evolution of s is governed by the conditional transition probability matrix, $\Gamma_{ss'}$, the probability of becoming disabled, the optimal decision to retire and the compulsory retirement at age 84. We assume that both immigrants and natives enter the economy as able workers, that they do not own any assets, and that they draw the stochastic component of their initial endowment of efficiency labor units from the invariant distribution of $s \in \mathcal{S}$. The evolution of a is determined by the optimal savings decision. Finally, the evolution of b is determined by the rules of the Spanish public pension system as described in expression (1) and in the paragraph that is immediately below that expression.

4 Calibration

The purpose of this paper is to evaluate the aggregate, distributional and welfare consequences of delaying the retirement age in Spain taking into account both the demographic and the educational transitions. To do this, we use the following calibration strategy: First, we choose 1997 as our calibration target year. We choose the model economy functional forms and parameters so that its main demographic, educational and economic statistics replicate as closely as possible the corresponding statistics of the Spanish economy in that year. Then we choose an initial steady state, which we identify with the year 1950.[10] The educational transition starts in 1951, the demographic transition starts in 1998, and both transitions end in 2131. In our model economy the age and education transitions are completely independent from the economic transitions, we have discussed them in detail elsewhere (see Díaz-Giménez and Díaz-Saavedra, 2006a) and, for the sake of brevity, we report them in Figure 1, but we do not discuss them here.

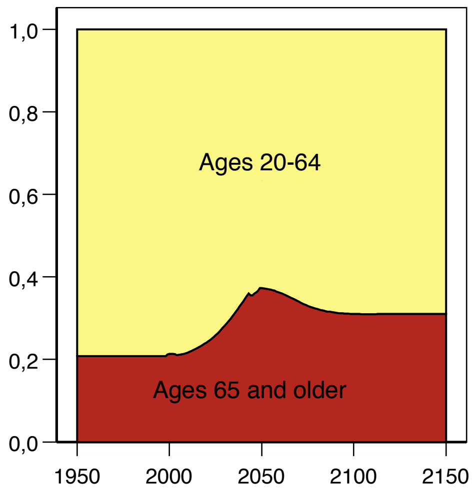
4.1 Functional forms and parameters

The next step in our calibration procedure is to choose specific forms for the functions that describe our model economy and specific values for their parameters. Our choices are the following:

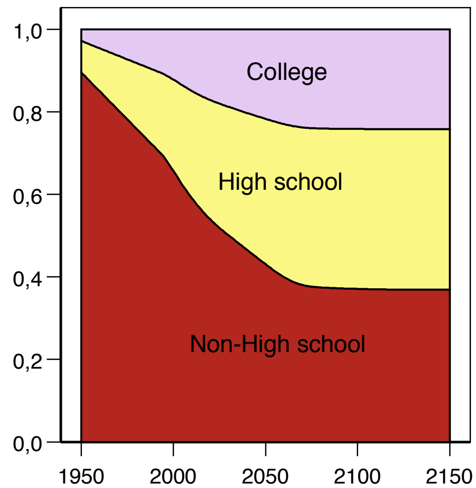
The Pension system. To characterize the public pension system, we must choose the functional forms for the payroll tax function, $\tau_s(y_t)$, and for the early retirement penalty function, $\lambda(j)$, and we must choose the values of the following parameters: the minimum and maximum retirement pensions, $\underline{b}_t$ and $\overline{b}_t$, the number of years of contributions used to compute the retirement pensions, N_b, the pension replacement rate, ϕ, the maximum covered earnings, a_{0t}, the first and the normal retirement ages, R_0 and R_1, the disability pension, b_{dt}, the initial

[10]The choice of the initial steady-state is somewhat arbitrary. We chose 1950 because it seems a reasonable starting year for the Spanish educational transition, and because it is a round number.

Figure 1: The Age and Educational Distributions in the Model Economy



Panel A: The age distribution



Panel B: The educational distribution

value of the pension fund, F_0, and the exogenous rate of return earned by the pension fund assets, r^*.

The Spanish payroll tax is a capped proportional tax. To replicate these properties we use the following two-parameter function:

$$\tau_s(y_t) = a_1 - \left[a_1(1 + a_2 y_t)^{-y_t}\right] \tag{23}$$

Parameter a_1 determines the payroll tax cap and the payroll tax rate is a function of parameter a_2. Panel A of Figure 2 represents this function for our chosen values of a_1 and a_2 (see below).

The Spanish *Régimen General de la Seguridad Social*, establishes that the penalties for early retirement are a linear function of the retirement age. To replicate this rule, our choice for the early retirement penalty function is the following

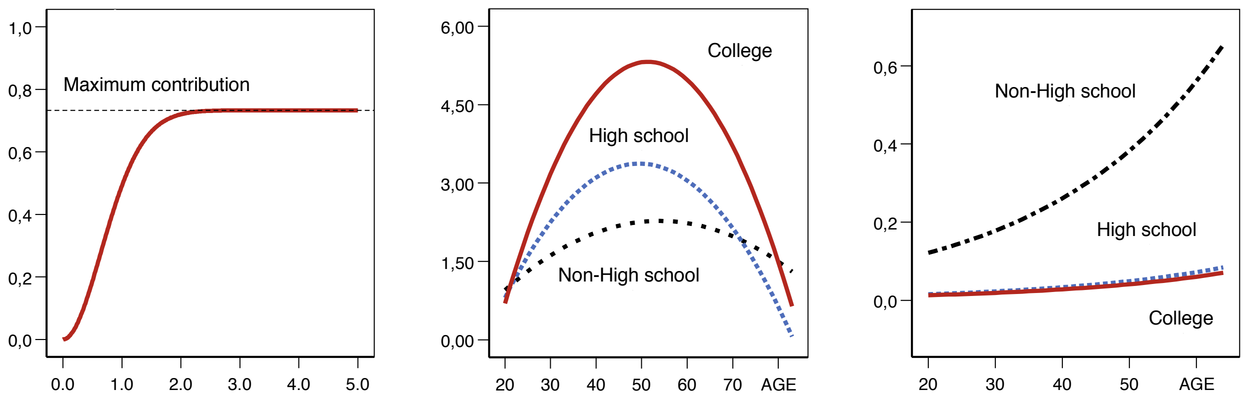
$$\lambda(j) = \begin{cases} \lambda_0 - \lambda_1(j - R_0) & \text{if } j < R_1 \\ 0 & \text{if } j \geq R_1 \end{cases} \tag{24}$$

where R_0 is the first retirement age and R_1 is the normal retirement age.

Government revenues and outlays. To characterize the government revenues and outlays, we must choose the values of the labor income tax rate, τ_{lt}, of the capital income tax rate, τ_{kt}, of the consumption tax rate, τ_{ct}, and of the government consumption, government transfers and government debt shares of output. Therefore, to characterize the government policy completely we must choose the values of a total of 20 parameters.

The deterministic component of the endowment of efficiency labor units process. We assume

Figure 2: The payroll tax, the endowment of efficiency labor units and the disability risk



Panel A: The payroll tax | Panel B: The E. of E. L. U. | Panel C: The disability risk (%)

that the deterministic component of the efficiency labor units profiles is determined by functions of the following form:

$$\epsilon(j,h) = a_{h1} + a_{h2}j - a_{h3}j^2 \tag{25}$$

This functional form captures the concavity workers' productivity profiles over their life-cycle in a very parsimonious way (see Panel B of Figure 2). Since we consider three educational levels, to characterize this function we must choose the values of nine parameters.

The stochastic component of the endowment of efficiency labor units process. We assume that the stochastic component of the endowment of efficiency labor units process, $s \in \mathcal{S}$, takes three values, that is, $\mathcal{S} = \{s_1, s_2, s_3\}$. We make this choice because we want to keep this process as parsimonious as possible, and because it turns our that three states are sufficient to account for the Lorenz curves of the Spanish distributions of income and labor earnings in very much detail. These choices imply that, to characterize the process on $s \in \mathcal{S}$, we must choose the values of 12 parameters: its three values and the nine conditional transition probabilities of matrix $\Gamma_{ss'}$.

Disability. We assume that the conditional probabilities of becoming disabled at age $j+1$ are determined by functions of the following form:

$$\varphi(j,h) = g_h a_4 e^{(j*a_5)} \tag{26}$$

We make this choice because, according to the *Boletín de Estadísticas Laborales*, the number of disabled people in Spain increases more than proportionally with age, and because the number of disabled households differs significantly across educational types (see Panel C of Figure 2).

To characterize these functions, we must choose the values of five parameters.[11]

Preferences. Our choice for the households' common utility function is:

$$u(c_j, 1 - l_j) = [c_j^{\alpha}(1 - l_j)^{(1-\alpha)}]^{1-\sigma}/(1 - \sigma) \tag{27}$$

Therefore, to characterize the household preferences we must choose the values of three parameters: α, σ and the time discount factor, β.

Technology. To describe the technology, we use a standard Cobb-Douglas aggregate production function, $Y_t = K_t^{\theta}(A_t L_t)^{1-\theta}$ where $A_{t+1} = (1 + \gamma)A_t$. Consequently, to determine the production technology, we must choose the values three additional parameters: the capital income share, θ the initial value of the labour augmenting productivity factor, A_0, the productivity growth rate, γ. To complete the description of the technology we must also choose a values for the capital depreciation rate, δ,

Adding up. To characterize our model economy fully, we must choose the values of a total of 53 parameters. Of these 53 parameters, 20 describe the government policy, 21 describe the endowment of efficiency labor units profiles, 5 describe the disability risk function, 3 describe the household preferences, and the remaining 4 describe the production technology.

4.2 Targets

We choose 1997 as our calibration year. This is because the the Lorenz curves of the Spanish income and earnings distributions which are our main calibration datasource are from that year. To find the values of the 53 model economy parameters, we need 53 equations or calibration targets which are the following:

4.2.1 Pension system rules

Minimum and maximum retirement pensions. The *Régimen General de la Seguridad Social* establishes various minimum retirement pensions that vary with the personal and economic circumstances of the recipient. In 1997, the minimum retirement pensions in Spain ranged from €768 to €5,427 per year. We could not find precise data on the number of people who receive each pension, but we know that the majority of the pensions range between €3,000 and €4,700. The lack of data made us target $\underline{b}_t = 0.30\overline{y}_t$, where $\overline{y}_t$ denotes average output in the model economy, since in 1997 30 percent the Spanish GDP was, approximately €3,744. That same year the maximum retirement pension payed by the *Régimen General* was €23,912. This number is approximately 1.91 times of the Spanish per capita GDP. Therefore, in our model economy we target $\overline{b}_t = 1.91\overline{y}_t$.

[11]The data on disability can be found at www.mtas.es/estadisticas/BEL/Index.htm.

Maximum covered earnings. In 1997 the maximum covered earnings were €32,300 which corresponded to 2.59 times the 1997 the Spanish per capita GDP. Consequently, in our model economy we target $a_{0t} = 2.59\overline{y}_t$.

Number of years of contributions. The Spanish *Régimen General de la Seguridad Social*, considers the last 15 years of contributions prior to retirement to compute the pension. Consequently, our choice for the number of years used to compute the retirement pensions in our model economy is $N_b = 15$.

Penalties for early retirement. In 1997 the Spanish *Régimen General de la Seguridad Social* established that the first retirement age is 60 and that the penalty for early retirement is 8 percent for every year before age 65.[12] Consequently, the maximum retirement penalty is 40 percent. We use these rules to determine the values of the values of λ_0, λ_1, R_0 and R_1 in expression (24) for the benchmark model economy. For the reformed model economy we change the first retirement age to 63 years and the normal retirement age to 68 years.

Disability pensions. The Spanish Social Security establishes the disability pensions are 75 percent of the household's retirement claim, and that there is a minimum disability pension which is equal to the minimum retirement pension. Consequently, in our model economy the disability pensions are determined by $b_{dt} = \max\{\underline{b}_t, 0.75b\}$.

Pension system fund. The Spanish public pension system fund received its first revenues in the year 2000. According to Balmaseda *et al.* (2006), from 2000 to the end of 2004 a total of €19,330 million were invested in the fund. This amount corresponds to 2.5 percent of Spanish GDP. Since the model economy fund starts in 2005, this is the amount that we choose for the fund's initial value. For the rate of return on the fund's assets we choose $r^* = 0.02$.[13]

4.2.2 Government outlays and revenues

To calibrate the government sector in our model economy, we replicate as closely as possible the 1997 Spanish Government Budget described in Table 2. Therefore, our task is to allocate the different revenue and expenditure items reported in that table to our model economy tax instruments and government outlays.

Pensions. We choose the replacement rate, ϕ, in expression (1) so that total expenditure in both retirement and disability pensions in our model economy is 10.1 percent of output. This was the share of pension payments to GDP in Spain in 1997.

Government Expenditures. In Spain in 1997 the sum of the shares of government consumption,

[12] This was changed in 2002 when the first retirement age was delayed to 61, except for some special cases.

[13] We also run simulations $r^* = 0.01$, $r^* = 0.03$ and $r^* = 0.04$. The only results that vary with r^* are the values of the pension fund, these changes are small and they do not modify the conclusions of this article.

Table 2: Tax Revenues and Public Expenditures in 1997

Revenues	%GDP	Expenditures	%GDP
Payroll Taxes	11.08	Consumption	17.53
Individual Income Taxes	7.35	Pensions	10.10
Production Taxes	5.42	Other Transfers	5.41
Sales and Gross Receipts Taxes	5.03	Interest Payments	4.20
Corporate Profit Taxes	2.75	Gross Investment	3.07
Estate Taxes	0.36	Other Expenditures	1.40
Other Taxes	0.40		
Other Revenues	6.23		
Total Own Revenues	38.62		
Deficit	3.09		
Total Revenues	41.71	Total Expenditures	41.71

Source: National Accounting reports (INE), and Boletín de Estadísticas Laborales 2001

gross investment and other expenditures was 22.0 (= 17.53+3.07+1.40) percent of GDP. This is the number that we target for our model economy's government expenditures to output ratio.

Other transfers. We target a value for the model economy's aggregate transfers to output ratio, Z/Y, of 5.41 percent. This value corresponds to share of transfers other than retirement and disability pensions to GDP in Spain in 1997.

Interest Payments. In Spain in 1997 interest payments on public debt accounted for 4.20 percent of GDP. This is the number that we target for the 1997 rD/Y in our model economy.

Payroll taxes. To identify the payroll tax function described in expression (23), we must choose the values of parameters a_1 and a_2. In Spain in 1997, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first €32,330 of annual gross labor income. Hence, the maximum contribution was €9,149 which correspond to 73 percent of the Spanish per capita GDP. To replicate this number, in our model economy we choose $a_1 = 0.73\overline{y}_t$. To select a value for a_2, we require that the revenues collected by the payroll tax in the model economy match the 11.08 percent of output collected in the Spanish economy.

Labor income taxes. We choose the model economy proportional labor income tax rate so that the revenues collected by this tax instrument in the benchmark model economy match the labor income tax revenues in the Spanish economy. According to the Spanish *Dirección General de Tributos*, labor income tax revenues accounted for 79.22 percent of the individual income tax revenues in 1997.[14] Since the total individual income tax revenues amounted to

[14]The data on income tax revenues is available at www.meh.es/Portal/Temas/Impuestos.

7.35 percent of Spanish GDP that year, we choose the model economy labor income tax rate so that it collects 5.82 ($= 7.35 \times 0.7922$) percent of the model economy output.

Capital income taxes. We choose the model economy proportional capital income tax rate so that it collects the sum of the corporate profit taxes revenues plus the share of the personal income tax revenues not imputed to labor. Therefore, we choose the model economy labor income tax rate so that it collects 4.28 ($= 2.75 + 7.35 \times 0.2078$) percent of the model economy output.

Consumption taxes. Choosing how to close the government budget has potentially important implications for policy reform evaluations. Some authors use lump-sum taxes for this purpose. We have not adopted this choice because lump-sum taxes are conspicuously absent from the current Spanish tax system. Once we have discarded lump-sum taxes, and keeping in mind that unintentional bequests are an additional source of revenues in our model economy, we faced the following two options: we could have chosen to keep the government debt share of GDP constant, thereby fixing the share of deficit financing, and used the consumption tax to close the government budget, or we could have targeted the consumption tax revenues and let the deficit vary to close the government budget. Since Spain is part of the European Monetary Union and is bound by the Growth and Stability pact to keep the debt to GDP ratio within reasonable limits, we chose the first one of these two options. Therefore, in our model economy we let the consumption tax rates vary endogenously to levy the revenues needed to satisfy the government budget.[15] The various choices described above give us a total of 20 targets.

4.2.3 Other targets

Endowment of efficiency labor units process. We want the deterministic component of the efficiency labor unit profiles of the educational groups in our model economy, $\epsilon(j,h)$, to approximate the corresponding profiles reported by the INE in the *Encuesta de Salarios en la Industria y los Servicios* (2000) for the Spanish economy. Since we approximate these empirical profiles with quadratic functions, we use the data to determine the values of the nine (a_{h0}, a_{h1}, a_{h2}) parameters of equation (25) directly. This gives us 9 additional equations.[16]

Disability. According to the INE, in 2002, in Spain, 80.9 percent of the total number of people who claimed to be disabled had not completed high school, 10.4 percent had completed high school, and the remaining 8.7 percent had completed college. We use these shares to determine the values for the g_h parameters of equation (26). Moreover, according to the *Boletín de Estadísticas Laborales*, in 2001 in Spain, 3.72 and 4.26 percent of the people in the

[15] Notice that unintentional bequests are endogenously determined in our model economy, and that every other expenditure and revenue item the government budget has already been targeted.

[16] Since we only have data until age 64, we estimate the quadratic functions for workers in the 20–64 age cohort and we project the resulting functions from age 65 onwards.

20–64 and in the 40–54 age cohorts received a permanent disability pension. To replicate these numbers, we set $a_4 = 0.0014$ and $a_5 = 0.0382$ in that same equation. These choices give us 5 targets.

Preferences. According to *Encuesta sobre el Tiempo de Trabajo* published by the INE, in 1996 in Spain the average number of hours worked was 1,648 per worker.[17] If we consider the endowment of disposable time to be 14 hours per day, the total amount of disposable time is 5,110 hours per year. Dividing 1,648 by 5,110 we obtain 32.2 percent which is the share of disposable time allocated to working in the market that we target. Next, we choose $\sigma = 4$. This choice and the share of consumption in the utility function, $\alpha = 0.363$, imply that the relative risk aversion in consumption is 2.089 which falls within the 1.5–3 range which is standard in the literature. These restrictions on preferences give us two targets.

Technology. Zabalza (1996) reports that 0.375 is the capital income share for the Spanish economy, and this is the value that we target for the capital income share of our model economy. Balmaseda *et al.* (2006), report that the average labor productivity growth rate in Spain for the period 1988–2004 was 0.6 percent, and this is our choice for the growth rate of total factor productivity in our model economy. These choices give us another 2 equations.

Macroeconomic aggregates. We still have to choose the targets for the model economy capital to output and investment to output ratios. According to the BBVA database, in 1997 the value of the Spanish private capital stock was €631,430 million 1986.[18] According to the INE, in 1997 the Spanish Gross Domestic Product was €265,792 million 1986. Dividing these two numbers, we obtain $K/Y = 2.38$, which is our target value for the model economy capital to output ratio. For the investment to output ratio we target a value of $I/Y = 18.80$ percent. This is the value reported by the INE for the gross private investment to output in 1997. These choices give us 2 additional targets.

The distributions of earnings and income. We target the two Gini indexes and six points of the Lorenz curves of the Spanish distributions of earnings and income as reported by Budría and Díaz-Giménez (2006) for 1997 (see Table 8). These choices give us 8 additional targets. Castañeda, Díaz-Giménez, and Ríos-Rull (2003) argue in favor of this calibration procedure when addressing issues where replicating the inequality observed in the data is important.

Normalization conditions. In our model economy there are five normalization conditions. The transition probability matrix on the stochastic component of the endowment of efficiency labor units process is a Markov matrix and therefore its rows must add up to one. This property imposes three normalization conditions. We also normalize the first realization of this process to be $s(1) = 1$. Next, we choose the initial value of the total factor productivity to be $A_0 = 1$.

[17] This data is available at $www.ine.es/inebase/cgi/um?M = \%2Ft22\%2Fp186\&O = inebase\&N = \&L =$.
[18] This number can be found at http://w3.grupobbva.com/TLFB/TLFBindex.htm.

Table 3: Values for 32 of the Model Economy Parameters in 1997

	Parameter	Value
Public Pension System		
Maximum covered earnings	a_0	5.7595
Payroll tax cap	a_1	1.6299
Payroll tax rate	a_2	0.0499
Maximum early retirement penalty	λ_0	0.4000
Yearly early retirement penalty	λ_1	0.0800
Minimum retirement pension	$\underline{b}_t$	0.6671
Maximum retirement pension	$\overline{b}_t$	4.2472
Minimum disability pension	$\underline{b}_d$	0.6671
Replacement rate	ϕ	0.5051
Number of years of contributions	N_b	15
First retirement age	R_0	60
Normal retirement age	R_1	65
Initial value of the pension fund	F_0/Y	0.0250
Pension fund rate of return	r^*	0.0200
Government Revenues and Outlays		
Labor income tax rate	τ_l	0.1109
Capital income tax rate	τ_k	0.1831
Consumption tax rate	τ_c	0.2625
Government consumption	G/Y	0.2196
Government transfers	Z/Y	0.0541
Government debt	D/Y	0.5223
Preferences		
Time discount factor	β	0.9908
Consumption share	α	0.3630
Curvature	σ	4.0000
Technology		
Labor share	θ	0.3750
Capital depreciation rate	δ	0.0782
Global factor productivity	A_0	1.0000
Productivity growth rate	γ	0.0060
Probability of Becoming Disabled		
	a_3	0.0014
	a_4	0.0382
	g_1	0.8090
	g_2	0.1040
	g_3	0.0870

These normalization conditions give us 5 additional equations.

Adding up. Notice that we have specified a total of 53 equations or targets. Of these 53 targets, 20 are related to the government policy, 9 to the deterministic component of the endowment of efficiency labor units process, 5 to the disability risk function, 2 are related to the household preferences, 2 to the production technology, 2 are macroeconomic aggregates, 8 target distributional statistics and the remaining 5 are normalization conditions. The 53 parameters and 53 targets define a full rank non-linear system of 53 equations in 53 unknowns.

4.3 Choices

We obtain values of some of the model parameters directly because they are determined uniquely by single targets. In this fashion, we have $\sigma = 4$, $\gamma = 0.006$, and $\theta = 0.375$. We obtain values for parameters λ_0 and λ_1 of the early retirement penalty function described in expression (24) directly from the rules of the *Régimen General de la Seguridad Social*. We obtain the values of the maximum covered earnings to output ratios, a_{0t}, the number of years of contributions that are taken into account to compute the retirement pensions, $N_b = 15$ and the values from the first and the normal retirement ages, $R_0 = 60$ and $R_1 = 65$ from the same source.

Similarly, the quadratic approximations to the empirical productivity profiles, allow us to obtain the nine values for parameters (a_{h0}, a_{h1}, a_{h2}) in expression (25). The values of the three parameters g_h, of a_3 and of a_4 of expression (26) were obtained directly from the INE. We arbitrarily chose $A_0 = 1$ and $r^* = 0.02$. We chose the initial value of the pension fund to be $F_{2005} = 2.5$ percent of the model economy output directly from Balmaseda *et al.* (2006). Finally, the normalization of the endowment of efficiency labor units implies that $s(1) = 1.0$.

Table 4: The Deterministic Component of the Endowment Process

	$h = 1$	$h = 2$	$h = 3$
a_{h0}	0.8523	0.6260	0.3950
a_{h1}	0.0821	0.1800	0.3040
a_{h2}	0.0011	0.0029	0.0046

The choices enumerated so far allow us to determine the values of 27 out of the 53 model economy parameters. To determine the values of the remaining 26 parameters, we solve the system of 26 non-linear equations in 26 unknowns obtained from imposing that the relevant statistics of the model economy should be equal to the corresponding targets.

Actually we solved a smaller system of 13 non-linear equations in 13 unknowns because our guesses for the values of aggregate capital and aggregate labor uniquely determine the values of a_1, b_d, $\underline{b}_t$, $\overline{b}_t$, Z, D, τ_k, and τ_l, because the value of G is determined residually from the G/Y target, because the value of τ_c is determined residually from the government budget constraint, and because the normalization of the matrix $\Gamma_{ss'}$ allows us to determine the values of three of the transition probabilities directly. Solutions for these systems are not guaranteed to exist and, when they do exist, they are not guaranteed to be unique. Consequently, we tried many different initial values in order to find the best parameterization possible.[19]

We report the numerical choices for 32 of the model economy parameters in Table 3, for the 9 parameters that describe the deterministic component of the endowment process in Table 4 and for the 12 parameters that describe the stochastic component of the process in Table 5. In this last table we also report the invariant distribution of the shocks implied by our choices.

Table 5: The Stochastic Component of the Endowment Process

		Transition Probabilities			
	Values	$s' = s_1$	$s' = s_2$	$s' = s_3$	$\pi^*(s)^a$
$s = s_1$	1.0000	0.6300	0.3138	0.0562	50.42
$s = s_2$	3.3394	0.4099	0.5894	0.0007	45.49
$s = s_3$	4.3255	0.0000	0.6977	0.3023	4.09

[a] $\pi^*(s)$% denotes the invariant distribution of s.

5 Findings: the benchmark model economy

5.1 The stochastic component of the endowment process

The procedure used to calibrate our model economy identifies the stochastic component of the endowment of efficiency labor units process. Since this is an important feature of our model economy, we start off this section describing its main properties which we report in Table 5. We find that to replicate the Spanish Lorenz curves of the income and earnings distributions in our model economy, the differences in the realizations of $s \in \mathcal{S}$ need not be very large. The highest realization is only 4.3 times the lowest realization of the process (see the first column of Table 5). In the next three columns of that table, we report the conditional transition probabilities of the process. We find that the process is not very persistent. Specifically, the expected durations of the shocks are 3.7, 2.4, and 1.4 years. The last column of the table reports the invariant distributions of the shocks. We find that approximately 96 percent of the workers are in states $s = s_1$ and $s = s_2$ and that only four percent are in state $s = s_3$.

[19] To solve this system we use a standard non-linear equation solver (specifically a modification of Powell's hybrid method, implemented in subroutine DNSQ from the SLATEC package).

Table 6: Macroeconomic Aggregates and Ratios in 1997 (%)

	C/Y	I/Y	G/Y^a	K/Y^b	h^c
Spain	59.2	18.8	22.0	2.38	32.2
Benchmark	56.2	21.8	22.0	2.36	28.3

[a]The G/Y ratio in Spain is the sum of all government outlays other than transfers and interest payments.
[b]The K/Y ratio is expressed in natural units and not in percentage terms.
[c]Variable h denotes the average share of disposable time allocated to the market.

5.2 Macroeconomic aggregates and ratios in 1997

We report the values of our aggregate targets for Spain and for the benchmark model economy in Tables 6 and 7. In Table 6 we show that the consumption and investment shares of output that are three percentage points off target, and that on average the share of the disposable time that the model economy households allocate to the market is four percentage points smaller than in the Spanish economy. In contrast, the capital to output ratio and the government expenditures to output ratio are very similar in both economies.

Table 7: The Government Budget in 1997 (%)

	G/Y^a	P/Y	Z/Y	INT/Y	T_s/Y	T_l/Y^b	T_k/Y^c	$\Delta D/Y$	E/Y^d	T_c/Y^e
Spain	22.0	10.1	5.4	4.2	11.1	5.7	4.3	3.1	7.0	10.5
Benchmark	22.0	10.2	5.4	4.2	11.0	5.7	4.3	3.1	3.3	14.3

[a]In the Spain this number is the sum of all government consumption, government gross investment and other government expenditures.
[b]In the Spain this number is the labor income share of the Personal Income Tax revenues.
[c]In the Spain this number is the sum of the Corporate Profit Tax revenues and the capital income share of the Personal Income Tax revenues.
[d]In the Spain this number corresponds to other government revenues and in the model economy to unintentional bequests.
[e]In the Spain this number is the sum of the Production Tax and the Sales and Gross Receipts Taxes and in the model economy it is the value that satisfies the government budget.

In Table 7 we show that our benchmark model economy does a great job in replicating the main items of the 1997 Spanish government budget. The benchmark economy accounts almost exactly for every expenditure item and for every revenue item with the exception of consumption tax collections and other government revenues. This last result was expected, since in our benchmark model unintentional bequests are the only “other Revenues”, and consumption taxes are determined residually to satisfy the government budget.

Table 8: The Distributions of Earnings, Income and Wealth in 1997

		Bottom Tail			Quintiles					Top Tail		
	Gini	1	1–5	5–10	1st	2nd	3rd	4th	5th	10–5	5–1	1
The Earnings Distributions (%)												
Spain[a]	0.57	0.0	0.0	0.0	0.0	2.5	15.6	27.3	54.8	13.4	14.7	6.6
Benchmark	0.52	0.0	0.0	0.2	1.3	3.7	15.9	29.0	50.0	12.4	14.1	5.2
The Income Distributions (%)												
Spain[a]	0.39	0.0	0.6	1.4	5.4	10.7	15.9	23.3	44.6	10.7	11.1	6.4
Benchmark	0.40	0.1	0.7	1.1	5.1	9.8	15.7	24.2	45.3	11.2	12.9	4.7
The Wealth Distributions (%)												
Spain[b]	0.57	-0.1	0.0	0.0	0.9	6.6	12.5	20.6	59.5	12.5	16.4	13.6
Benchmark	0.53	0.0	0.0	0.0	0.7	6.1	14.5	25.7	52.9	12.9	14.8	6.0

[a]The source of data for the Spanish income and earnings distribution is the 1997 European Community Household Panel as reported in Budría and Díaz-Giménez (2006a).
[b]The source of data for the Spanish wealth distribution is the 2004 Encuesta Financiera de las Familias Españolas as reported in Budría and Díaz-Giménez (2006b).

5.3 Inequality in 1997

In Table 8 we report the Gini indexes and selected points of the Lorenz curves of earnings, income and wealth in Spain and in our benchmark model economy in 1997. Our main finding is that our model economy replicates the Spanish earnings and income distributions in very much detail. If we look at the fine print, we find that earnings is somewhat more unequally distributed in Spain, and that income is marginally more unequally distributed in the model economy.

On the other hand, we find that wealth is significantly more concentrated in Spain than in our model economy. This result was expected for two reasons: first, Díaz-Giménez and his coauthors we have argued elsewhere that, in general, overlapping generations economies fail to account for the large concentrations of wealth observed in the data (see Castañeda *et al.*, 2003) and, second, the variance of its realizations is very small because we have not used any of the points of the Lorenz curve of wealth as part of our calibration targets.

5.4 Retirement behavior in 1997

Perhaps the single most important feature of the Spanish economy that our model economy should replicate if we are to take its results seriously, is the retirement behavior of Spanish households. To describe this behavior, we compare some of the labor market statistics and the conditional probabilities of retirement in Spain and in our model economy.

Average retirement age. In the first panel of Table 9 we report the average retirement age in

Spain and in our benchmark model economy. We find that the average retirement age in our model economy is 60.1 years, which is only 0.3 years less than in the Spanish economy.[20] We also find that the average retirement age is increasing in the number of years of education. The average retirement ages for non-high school, high school, and college workers are 59.1, 61.7, and 62.6 years. We do not have the corresponding data for the Spanish economy but we think that this increasing relationship is intuitively plausible.

The sixty year old retirees. In 1995 in Spain 29.5 percent of the 60 year old workers chose to retire, and in our model economy this number is 31.5. Of these first-age retirees, in Spain 67.7 percent received the minimum pension. In our model economy this number is 52.7 percent.[21] This discrepancy between model and data is partly due to the fact that in our model economy we do not take into account the number of years of contributions to determine the retirement pension. Consequently the pension entitlements of the model economy households are higher than those in the Spanish economy. In the middle panel of Table 9 we report the educational distribution of the 60 year-old retirees in our benchmark model economy. We find that the vast majority (79 percent) have not completed high school. We also find that many of these households (63 percent) receive the minimum pension. In contrast, the shares of the 60 year old retirees who have completed high school and college and receive the minimum pension are very much smaller (15 percent and 13 percent). These findings confirm that education and minimum pensions play important roles in the retirement decisions.

Table 9: Retirement and labor market participation in 1997 (%)

	Avg Retirement Ages		Retirees of Age 60[a]		Participation Rates (60-64)	
	Spain	Benchmark	Spain	Benchmark	Spain[b]	Benchmark
Total	60.4	60.1	29.5	31.5	28.1	36.1
Non-High School	*n.a.*	59.1	*n.a.*	78.7	25.9	29.6
High School	*n.a.*	61.7	*n.a.*	16.3	38.5	43.8
College	*n.a.*	62.6	*n.a.*	5.0	57.7	61.7

[a]The share of the 60 year-old retirees for Spain corresponds to 1995. (Source: Sánchez-Martín, 2003).
[b]The Spanish data is the average of the four quarters of the 1997 *Encuesta de la Población Activa*.

The labor market behavior of the 60 to 64 year-olds. In 1997 in Spain the average employment rate of the 60 to 64 year-old households was 26.0 percent and their average participation rate was 28.1 percent. In our model economy the average employment rate was 36.1 percent.[22] These numbers confirm that old people work more in our model economy than in Spain. This

[20]The Spanish average retirement age has been computed for both male and female workers, it corresponds to the year 1995 and it is reported in Blöndal and Scarpetta (1997). Every number reported in this section for our model economy corresponds to the year 1997.

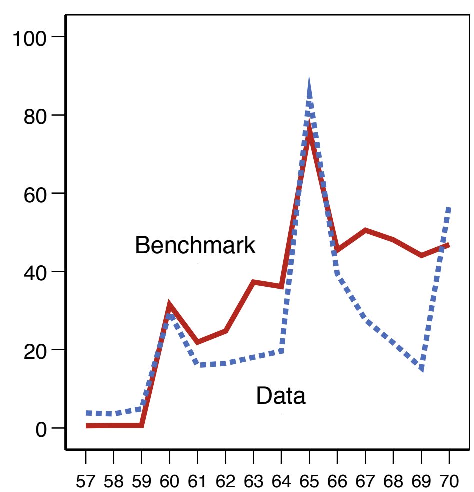
[21]The share of the Spanish 60 year old retirees who receive the minimum pension corresponds to the year 1995 and it is reported in Sánchez-Martín (2003).

[22]Since in our model economy we abstract from unemployment, the employment rates and the participation rates coincide.

discrepancy can be justified in part by the very low participation and employment rates of Spanish women that are obviously absent from our model economy. In the last panel of Table 9 we report the participation rates of the educational types in Spain and in our model economy. In our three educational categories these participation rates are about four percentage points higher in our model economy. This means that our model economy overestimates the Spanish employment rates since we abstract from unemployment. This notwithstanding, we find that both in our model economy and in the data the participation rates of the elderly are clearly increasing in education. Two reasons justify this relationship. First, many non-high school workers are entitled to minimum pensions only, they are not affected by the early retirement penalties and, consequently, they choose to retire as early as possible. And second, even though all the educational types value leisure equally, the foregone labor income —which is the opportunity cost of leisure– is smaller for the households with less education. Consequently, the less educated workers choose to retire earlier than their more educated colleagues.

The retirement behavior of disabled households. As far as the retirement behavior of the disabled households is concerned, it turns out that all the disabled households in our model economy choose to retire at age 65 and, consequently, that they collect their full retirement pensions. We have not found data on the retirement behavior of disabled households in Spain, and it is hard to guess how many of them choose to retire early.

Figure 3: Conditional Probabilities of Retirement (%)



Retirement hazards. Finally, in Figure 3 we compare the conditional probabilities of retirement in Spain and in our model economy.[23] We find that our benchmark model economy replicates reasonably well the retirement peak observed in Spanish data at age 60. The observed proba-

[23] The Spanish data corresponds to Spanish males in the year 1995 and it is reported in Sánchez-Martín (2003).

bility of retirement at age 60 in Spain is 29.5 percent and in our benchmark model economy it is 31.5 percent. Our model economy also replicates for the retirement peak observed in Spain at age 65. The probability of retiring at age 65 is 85.0 percent in Spain, and in our model economy it is 76.1 percent.

Finally, our model economy accounts for the increasing probability of retirement between ages 61 and 64 observed in the data. This is because the profile of the endowment of efficiency labor units decreases steeply in the last part of the life-cycle and this reduces the rewards to working at older ages. More specifically, in our benchmark model economy if the average worker chooses to work for one more year after age 60, his pension entitlement decreases since his average labor earnings are smaller than the average earnings of the previous 15 years.[24]

Figure 3 also shows that the probabilities of retiring between ages 61 to 64 are lower in Spain than in our benchmark model economy. One reason that could account for these differences is that in Spain the pension replacement rate is an increasing function of the number of years of contributions, and in our model economy the replacement rate is independent of this number. Consequently the retirement hazard after age 60 is higher in our model economy.

Finally, we find that the probabilities of retiring are very different in Spain and in our model economy after age 66. In the Spanish economy this probability decreases until age 69 and then it increases quite sharply at age 70. In contrast, in the model economy the probabilities of retiring after age 66 are relatively constant. It is hard to find an intuitive reason to justify these discrepancies which Jiménez-Martín and Sánchez-Martín (2003) attribute to a “combination of institutional factors and firm decisions”.

5.5 Growth rates

Sizable slowdown. In Panels D and F of Figure 5 we represent time series for the output and the population growth rates in the benchmark model economy for the 2000–2100 period. We find that there is a sizable slowdown in the growth rates of output and that his is mainly because of the decreasing population growth rates. Between 2005 and 2010 the average population growth rate is approximately 1 percent, between 2011 and 2020 it is 0.6 percent, and between 2021 and 2030 it is only 0.4 percent. This implies that the average growth rate of the benchmark model economy output is 1.8 percent between 2005 and 2020, but only 0.7 percent between 2021 and 2060.

[24]See Boldrin, Jiménez-Martín and Peracchi (1999) for a discussion of this feature of the Spanish pension system.

6 Findings: delaying retirement

We study the aggregate, distributional and welfare consequences of delaying the first retirement age from 60 to 63 and the normal retirement age from 65 to 68. We assume that this change is adopted in 2010, that it was completely unexpected, and that it affects every household who had not retired by the end of 2009. To make the comparisons meaningful, both economies are identical in everything except in the payroll tax collections, in the pension payments, and in the unintentional bequests, which are endogenous, and in the consumption tax rates, which we adjust to satisfy the government budget.

6.1 Aggregate changes

Table 10: Average Annual Growth Rates and Accumulated Growth in 2009–60 (%)

	Avg Growth Rates in 2009-60 (%)			Accumulated Growth in 2009-60 (%)		
	Benchmark	Reform	$R-B$	Benchmark	Reform	$R-B$
Output	1.01	1.07	0.06	66.8	72.6	5.8
Capital	1.16	1.25	0.09	79.7	87.9	8.2
Labor	0.90	0.96	0.06	58.2	62.6	4.4
Hours	0.09	0.13	0.04	4.4	6.9	2.5
Workers	0.13	0.22	0.09	7.2	12.2	5.0
Consumption	1.37	1.36	–0.01	100.1	99.1	–1.0

In Table 10 we report the average and the accumulated growth rates of the main macroeconomic aggregates in the benchmark and in the reformed model economies between 2009 and 2060. In Figure 5 and in Panels A through I of Figure 6 we represent the time series of those and other aggregates, and of prices. Our main findings are the following:

Small changes. The aggregate changes brought about by the reform are small. The accumulated differences between 2009 and 2060 range from 8.2 percent in the case of the capital stock to –1.0 percent in the case of consumption (see the last column of Table 10).

The reform is slightly expansionary. Between 2009 and 2060 the reform brings about an increase in the average growth rate of output of approximately 0.06 percent per year which results in a difference between the accumulated growth rates of 5.8 percentage points by 2060. Both the capital and the labor inputs increase with the reform, but the increase in the capital input almost doubles the increase in the labor input. Consequently, the reform brings about an increase in the capital to labor ratio which is 1.8 percent higher in the reformed economy in 2060 (see Panels G through J of Figure 5).

The reform lowers consumption. Consumption is smaller after the reform but the size of the changes is tiny (see Panels K and L of Figure 5). Workers increase their consumption because of the higher wage rate, the longer working period, and the lower consumption tax rate. However, this is more than compensated by the lower consumption of the retirees who receive lower retirement pensions and face a lower real interest rate.

The reform increases the number of workers. Since we endogenize the retirement decision, the numbers of workers in our model economies are also endogenous and they differ sizably. Not surprisingly, delaying the retirement age increases the numbers of workers (see Panel A, B, and C of Figure 6).

The reform increases aggregate hours and hours per capita but it decreases hours per worker. The reform increases the number of hours worked and it also increases the number of hours worked per capita (see Panels D and E of Figure 6). However the behavior of these two series between 2010 and 2053 is very different. Aggregate hours increase continuously until 2033 and then they decrease slightly until 2050. In contrast, hours per capita increase immediately after the reform, they peak in 2012, and they decrease afterwards until 2053. The consequences of the reform for the numbers of hours per worker are also very different. We find that the increase in the number of workers brought about by the reform is larger than the increase in total hours and, consequently, the reform reduces the number of hours per worker (see Panels F and G of Figure 6). Since the accumulated increases of both the number of hours and the number of workers are smaller than the increase in output (2.5, 5.0, and 5.8 percent) these two measures of labor productivity increase after the reform.

Lower interest rates and higher wages. The reform lowers the real interest rate and it increases the wage rate. The accumulated growth rates of the wage rate between 2009 and 2060 in the benchmark and in the reformed model economies are 17.6 and 18.4 percent. In 2060, the real interest rates are 6.89 and 6.71 percent (see Panels H, and I of Figure 6). Since we assume that the technology is Cobb-Douglas and that markets are perfectly competitive, the shape of the time path of the capital to labor ratio is identical to the shape of the time path of the wage rate. It is interesting to notice that this shape is very similar to the time path of the old age dependency ratio (compare Panel A of Figure 1 with Panel I of Figure 6). This result is a consequence of the fact that the old tend to be the owners of capital and the young tend to be the suppliers of labor.

Lower consumption tax rates. The reform lowers consumption tax rate needed to balance the government budget. This is because total government outlays are a smaller proportion of output after the reform (see Panel J of Figure 6).

Table 11: Average Retirement Pensions and Ages (changes between 2009 and 2060)

	Average Retirement Pensions						Average Retirement Ages					
	E_{09}	B_{60}	R_{60}	Δ_{B1}	Δ_{R1}	Δ_{P60}	E_{09}	B_{60}	R_{60}	Δ_{B2}	Δ_{R2}	Δ_{A60}
All	0.89	1.17	1.08	31.5	21.3	–7.7	61.0	63.5	65.3	2.5	4.3	1.8
College	1.31	1.63	1.52	24.4	16.0	–6.7	63.8	65.2	66.8	1.4	3.0	1.6
High school	1.06	1.20	1.07	13.2	0.9	–10.8	62.2	63.2	65.1	1.0	2.9	1.9
No-high school	0.81	0.95	0.91	17.3	12.3	–4.2	60.1	62.8	64.5	2.7	4.4	1.7

–Columns E_{09} contain the average retirement pensions or ages in 2009.
–Columns B_{60} and R_{60} contain the average retirement pensions or ages in 2060.
–Columns Δ_{B1} and Δ_{R1} contain the percentage differences between the average retirement pensions between 2060 and in 2009.
–Column Δ_{P60} contains the percentage differences between the average retirement pensions in 2060 in the Benchmark and in the Reformed model economies.
–Columns Δ_{B2} and Δ_{R2} contain the differences in years between the average retirement ages in 2060 and in 2009.
–Column Δ_{A60} contains the difference in years between the average retirement ages in 2060 in the Benchmark and in the Reformed model economies.

6.2 Average retirement ages and average pensions

In Table 12 we report the values of the average pensions and the average retirement ages for 2009 and for 2060 and in Panels K and L of Figure 6 we represent the time series of these variables. Our main findings are the following:

Retirement pensions. In 2060 the average retirement pension in the reformed economy is 7.7 percent smaller than in the benchmark economy. Pensions are smaller in the reformed economy because the deterministic component of the endowment profile is decreasing and because households pay more early retirement penalties. By educational groups, the average pensions are 6.7, 10.8 and 4.2 percent smaller in the reformed model economy. The households who have not completed high school face smaller reductions in their pensions because their endowment profiles are flatter and because they pay less early retirement penalties, since many of them receive the minimum pension.

Retirement ages. Between 2009 and 2060 the average retirement age is delayed by 2.5 years in our benchmark model economy. The educational transition justifies this delay. Since more educated households choose to retire at older ages, as the model economy workers become more educated the average retirement age increases (see Panel L of Figure 6).[25]

In the reformed economy the average retirement age increases by 4.3 years between during that same period. Therefore, even though the reform delays the first and the normal retirement ages

[25] Jiménez-Martín (2006) shows that this change is already taking place in Spain. He attributes the observed increases in the participation rates of workers in the 55-64 cohort, specially of women, to the increases in the educational attainment of Spanish workers.

by three years, the difference in the average retirement ages of the benchmark and the reformed economies is only 1.8 years by 2060. The fact that the average retirement age increases by only 1.8 years means that a larger number of households choose to retire early in the reformed model economy in spite of the early retirement penalties. Boldrin and Jiménez (2003) obtain a similar result. Specifically, they find that despite a delay in 3 more years the first and the normal retirement ages, the maximum of the social security wealth for an average worker covered by the *Régimen General de la Seguridad Social* is delayed by only two years.[26]

As far as the educational differences are concerned, not surprisingly we find that the average retirement ages both in the benchmark and in the reformed economy are increasing in the educational attainment of households. This is because of the sizable educational differences in the deterministic component of the endowment of efficiency labor units.

6.3 The sustainability of the public pension system

Table 12: The Finances of the Public Pension System

	2009	2010	2020	2030	2040	2050	2060
	The Payroll Tax Collections (% GDP)						
Benchmark	11.0	11.0	11.2	11.3	11.3	11.1	11.1
Reform	–	11.0	11.2	11.4	11.4	11.3	11.3
	The Aggregate Pension Payments (% GDP)						
Benchmark	10.4	10.4	11.4	13.0	15.4	17.5	18.1
Reform	–	10.0	9.7	10.9	12.7	14.4	15.0
	The Pension System Deficits (% GDP)						
Benchmark	–0.6	–0.6	0.2	1.7	4.2	6.4	7.0
Reform	–	–0.9	–1.5	–0.5	1.2	3.1	3.7
	The Pension System Funds (% GDP)						
Benchmark	6.1	6.8	9.9	1.9	–30.3	–97.3	–194.9
Reform	–	7.1	25.2	41.5	46.7	32.6	1.1

In Table 12 we report the values of the payroll tax collections, the pension payments, the pension system deficits and the pension system funds for selected years, and in Panels A, B and C of Figure 7 we represent the time series of these variables. Our main findings are the following:

The reform delays in 15 years the first deficit of the public pension system. Specifically, in the benchmark economy the pension system starts running a deficit in the year 2019 and in the reformed economy in the year 2034 (see panel B of Figure 7). These differences are mostly due to the sizable reduction in pension payments. Payroll tax collections expressed as a share

[26]The social security wealth at age j is defined as the expected present value at age j of future pension benefits.

of output are very similar in the benchmark and in the reformed economies (see the top two blocks of Table 12 and panel A of Figure 7). As we have already mentioned, pension payments are smaller in the reformed economy because the reform reduces the average retirement pension and it increases the average retirement age.

The public pension system is sustainable until 2061 in the reformed economy. These changes imply that the reform makes the pension system sustainable until the year 2061. In the benchmark economy the pension system fund runs out in the year 2031, while in the reformed economy it lasts until the year 2061 (see panel C of Figure 7). These results imply that in 2060 in the benchmark economy the pension system fund is –194.9 percent on output in the red, while in the reformed economy it is 1.1 percent of output in the black.

Table 13: The Distributions of Earnings, Income and Wealth in 2060 (%)

		Bottom Tail			Quintiles					Top Tail		
	Gini	1	1–5	5–10	1st	2nd	3rd	4th	5th	10–5	5–1	1
The Earnings Distributions (%)												
Benchmark (2009)	0.525	0.0	0.0	0.1	0.9	3.4	16.4	28.9	50.3	12.3	13.7	4.7
Benchmark (2060)	0.506	0.0	0.1	0.3	1.5	4.0	16.3	29.5	48.8	12.7	12.4	4.2
Reform (2060)	0.512	0.0	0.0	0.3	1.4	3.8	16.3	29.2	49.3	12.6	12.9	4.3
The Income Distributions (%)												
Benchmark (2009)	0.405	0.1	0.7	1.2	5.1	9.5	15.6	24.9	44.9	11.1	12.8	4.3
Benchmark (2060)	0.403	0.1	0.7	1.2	5.3	10.2	15.2	23.5	45.9	11.4	13.1	4.2
Reform (2060)	0.411	0.1	0.7	1.2	5.3	9.9	14.7	23.5	46.6	11.6	13.3	4.2
The Wealth Distributions (%)												
Benchmark (2009)	0.528	0.0	0.0	0.0	0.8	6.2	14.2	25.2	53.4	13.1	15.1	5.8
Benchmark (2060)	0.527	0.0	0.0	0.0	0.8	6.4	14.0	25.2	53.6	13.6	14.8	5.1
Reform (2060)	0.528	0.0	0.0	0.0	0.8	6.2	14.0	25.5	53.5	13.7	14.6	5.1

6.4 Inequality

In Table 13 we report the shares of various groups of the earnings, income, and wealth distributions in the benchmark and in the reformed model economies in 2009 and in 2060. In Panels D through G or Figure 7 we represent the time series of the Gini indexes these three variables and pensions for the 2000–2100 period. Our main findings are the following:

The reform brings about small increases in earnings, income, and wealth inequality. The increase in the inequality of income is the largest, and the increase in the inequality of wealth is the smallest, and it is tiny. These results are related to the fact that workers with little education reduce their hours of work by more than the more educated workers.

The reform reduces the inequality of pensions. This is because the pensions of more educated households decrease more than those of households with less education.

7 Welfare

Let $z \in \Re = \mathcal{L}{\times}J{\times}H{\times}S{\times}A{\times}B$. To carry out the welfare comparisons, we define $v_B\left[z, \Delta(z)\right]$ as the value for of a household of type z of receiving, between 2010 and 2060, its optimal consumption allocation increased by a fraction $\Delta(z)$ and its optimal leisure allocation.[27] Formally,

$$v_B\left[z, \Delta(z)\right] = \sum_{t=0}^{\mathcal{J}-j} \beta^t\, \psi_{2010+t}(j+t)\, u\left\{c_{B2010+t}(z)\left[1+\Delta(z)\right], 1 - l_{B2010+t}(z)\right\} \tag{28}$$

where $c_{Bt}(z)$ and $1 - l_{Bt}(z)$ are the values of consumption and leisure that solve the household decision problem defined in expressions (11), (12), and (13). Next, for each household of type z, we define the welfare gain of the reform as the fraction of additional consumption, $\Delta_R(z)$, that is needed to attain in the benchmark model economy the welfare of the reformed model economy. Formally, $\Delta_R(z)$ is the solution to the equation

$$v_B\left[z, \Delta_R(z)\right] = v_R\left(z\right) \tag{29}$$

where $v_R(z)$ is the value of the optimal consumption and leisure allocation in the reformed model economy between 2010 and 2060.

To calculate the social welfare costs of a reform in any period t, we aggregate the individual welfare costs measured in terms of current period consumption as follows:

$$w_{Rt} = \int_{\Re} c(z)\Delta_R(z) d\mu_t \tag{30}$$

Finally, to compute the total social welfare costs of a reform during a number of years $t = 0, 1, \ldots, T$, we compute the present value of the social welfare costs, $\{w_{Rt}\}_{t=0}^{T}$, using the sequence of equilibrium interest rates of the benchmark model economy as the deflators. Formally, the total social welfare cost of a reform between 2010 and 2060 is

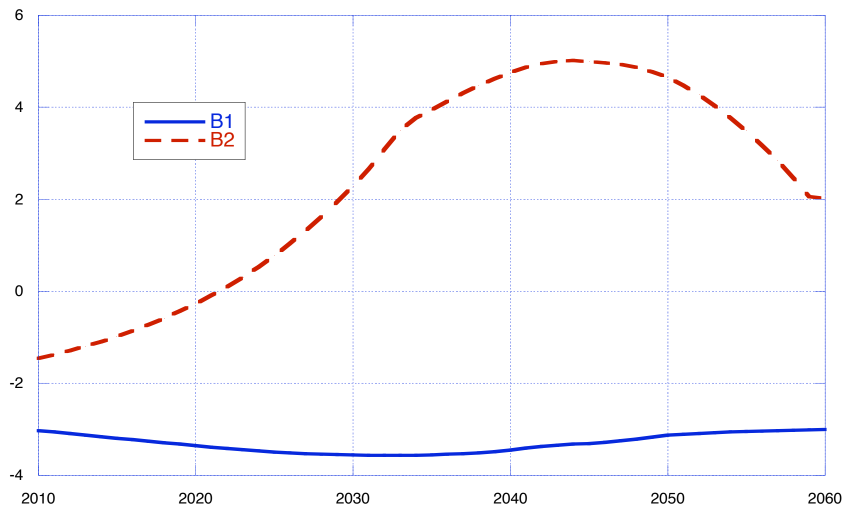
$$w_R = w_{R2010} + \sum_{t=2011}^{2060} \frac{w_{Rt}}{\Pi_{j=2011}^{t}(1+r_j)} \tag{31}$$

7.1 Social welfare changes

We find that between 2010 and 2060 delaying retirement by three years in our benchmark model economy results in a social welfare loss which is equivalent to 3.3 percent of the present value of the aggregate flow of consumption in the benchmark model economy during those

[27] Naturally, if a household dies before 2060 we compute the value of its optimal allocation while it is alive.

Figure 4: The Aggregate Welfare Costs of Delaying Retirement (%)



years. The solid line of Figure 4 represents the values of the social welfare cost each period expressed as a percentage of that period's aggregate consumption. These social welfare costs increase monotonically from 3.03 percent of aggregate consumption in 2010 to 5.57 percent in 2034. After that year they decrease monotonically to 3.01 percent of consumption in 2060.

In some sense, however, moving the pension system off-budget and allowing the pension fund to run an unbounded deficit, as we do in our original benchmark model economy, *B1*, is similar to allowing for some sort of a free lunch. Delaying retirement in this model economy is welfare decreasing because average pensions decrease, and because average leisure also decreases. To eliminate this free lunch, we evaluate the social welfare costs of delaying retirement in a second benchmark model economy, *B2*, in which consumption taxes are raised to finance the pension system deficits once the pension fund is exhausted. Every other feature is identical both in the two benchmark and in the two reformed model economies.

Delaying retirement in model economy *B2* opens up an interesting margin. This is because, under the current pension system rules, the pension fund runs out in 2032 and, consequently, the consumption tax must be raised from 2033 onwards. On the other hand, when the retirement ages are delayed, the pension fund is not exhausted until 2059, twenty seven years later and, consequently, in the reformed model economy, *R2*, consumption taxes must be raised only from 2060 onwards. The welfare costs of delaying retirement in model economy *B2* are smaller because, even though the average pension and the average allocation of leisure are reduced just as they were in our original benchmark model economy, when retirement is delayed the consumption taxes will also be sizably lower. Which one of these two counteracting effects will dominate is hard to predict before carrying out this second computational exercise.

It turns out that the lower consumption taxes more than compensate for the reduced pensions and leisure. Specifically, between 2010 and 2060 delaying retirement in model economy *B2* brings about a social welfare gain which is equivalent to 0.57 percent of the present value of its aggregate flow of consumption during those years. The dotted line of Figure 4 represents the values of the period social welfare gains of delaying retirement in model economy *B2* expressed as a percentage current aggregate consumption. We find that the social welfare gains brought about by the reform increase monotonically from –1.46 percent of aggregate consumption in 2010 to –0.09 percent in 2021. In 2022 the social welfare costs become social welfare gains, and they increase monotonically until they reach 5.01 percent of aggregate consumption in 2044. After that year, the welfare gains decrease monotonically to 2.02 percent of consumption in 2060.

Delaying retirement in this second model economy improves the welfare of young households who benefit from the reduced life-time taxation, and it penalizes middled age and old households who enjoy the reduced taxation for shorter periods and still have to suffer the reductions in leisure and pensions. As we move away from the year of the reform, the share of households who benefit from the lower life-time taxes increases. Since, in this second reformed model economy the pension fund runs out in 2059 and consumption taxes have to be raised in 2060, the welfare gains decrease as that year approaches.

7.2 The distribution of the welfare changes

In our model economies the numbers of workers and retirees change endogenously. Therefore, it makes little sense to compare the aggregate social welfare losses of the various age, education, and wealth groups of workers and retirees. Instead, to get an idea of the distribution of the welfare changes, we evaluate these changes for samples of households who stand-in for the corresponding age, education and wealth groups. In Table 14 we report the welfare changes of delaying retirement in model economies *B1* and *B2*. In the left-hand side block of the table we report the average welfare gains of delaying retirement for the households who were alive in 2010, and in the right-hand side block we report the average welfare gains for the households who were alive in 2035.

For instance, in the first cell of the first block of that table we report the average welfare cost of delaying retirement in model economy *B1* for the households who were 20 years old in 2010, had not completed high school, owned no assets, and had the average pension claims of all the households in that age and education group was equivalent to a reduction of 1.47 percent in its optimal allocation of consumption. To obtain this welfare change we do the following: we calculate the average welfare changes defined in expression (29) for three samples

Table 14: The Distribution of the Welfare Gains (%)

Welfare Gains of Delaying Retirement in Model Economy B1								
	Households Alive in 2010				Households Alive in 2035			
Age	W00	W10	W50	W90	W00	W10	W50	W90
No High School								
20	–1.47	–	–	–	–1.25	–	–	–
30	–1.89	–1.90	–2.03	–	–1.76	–1.78	–2.08	–
40	–2.54	–2.55	–2.62	–2.55	–2.56	–2.59	–2.77	–2.80
50	–3.78	–3.80	–3.80	–3.52	–3.79	–3.83	–4.02	–3.61
60	–7.71	–7.73	–6.75	–5.60	–7.10	–7.16	–6.94	–5.65
70	–0.69	–	–0.73	–0.81	–0.66	–	–0.96	–1.27
High School								
20	–1.66	–	–	–	–1.46	–	–	–
30	–2.35	–2.37	–2.49	–	–2.24	–2.26	–2.52	–
40	–3.44	–	–3.44	–2.90	–3.37	–3.39	–3.54	–3.23
50	–5.28	–5.30	–5.35	–4.41	–5.78	–5.82	–6.03	–5.29
60	–10.55	–10.58	–10.13	–8.66	–9.88	–9.94	–9.62	–8.60
70	–0.73	–0.73	–0.75	–0.81	–0.72	–0.73	–0.94	–1.20
College								
20	–1.24	–	–	–	–1.05	–	–	–
30	–1.85	–1.86	–2.00	–	–1.63	–1.65	–1.87	–
40	–2.58	–2.59	–2.70	–2.79	–2.35	–2.36	–2.56	–2.81
50	–3.84	–	–4.03	–4.06	–3.50	–	–3.78	–3.97
60	–5.79	–5.80	–5.97	–5.74	–6.37	–6.40	–6.63	–6.74
70	–0.75	–0.75	–0.77	–0.81	–0.76	–	–0.93	–1.15
Welfare Gains of Delaying Retirement in Model Economy B2								
No High School								
20	0.77	–	–	–	5.26	–	–	–
30	0.27	0.28	0.63	–	4.89	4.92	5.20	–
40	–0.65	–0.67	–0.32	0.44	4.12	4.14	4.53	5.34
50	–2.32	–2.33	–1.98	–1.14	2.66	2.67	3.15	4.57
60	–6.91	–6.95	–5.71	–4.16	–0.79	–0.80	0.16	2.75
70	–0.48	–	–0.36	–0.23	7.12	–	7.52	7.90
High School								
20	–0.31	–	–	–	4.88	–	–	–
30	–0.23	–0.23	0.00	–	4.30	4.31	4.54	–
40	–1.56	–1.56	–1.29	–0.15	3.13	3.14	3.45	4.56
50	–3.88	–3.90	–3.69	–2.25	0.36	0.36	0.67	2.32
60	–9.81	–9.85	–9.18	–7.38	–3.72	–3.74	–2.84	–0.80
70	–0.49	–0.49	–0.40	–0.28	7.11	7.14	7.43	7.78
College								
20	0.34	–	–	–	5.10	–	–	–
30	0.17	0.18	0.32	–	4.77	4.79	4.99	–
40	–0.68	–	–0.61	–0.35	4.07	–	4.23	4.50
50	–1.94	–1.97	–1.95	–1.71	2.89	–	3.00	3.38
60	–4.97	–5.00	–5.01	–4.57	0.00	0.00	0.23	0.77
70	–0.50	–	–0.43	–0.31	7.10	7.13	7.38	7.70

of 100 households each whose idiosyncratic shocks in 2009 were s_1, s_2 and s_3, and we report the weighted average of these three sample averages obtained using as weights the invariant distribution of $s \in \mathcal{S}$, π_s^*.

In the columns labeled $W = 10\%$, $W = 50\%$ and $W = 90\%$ of Table 14 we report the average welfare changes for households who owned the tenth, median and ninetieth percentile wealth of the wealth distribution of the corresponding benchmark model economy in 2010 or in 2035. When a cell of that table has no entry it is because there were no households in that age and education group who owned the amount of wealth that corresponds to the percentile indicated in the header of the column.

For the reasons that we have discussed above, we find that reforming the pension system in model economy *B2* is less costly than reforming a model economy in model economy *B1*, for every age, education, wealth group and year that we consider. Moreover, we find that the welfare gains of delaying retirement in model economy *B2* are sizably larger for the households alive in 2035 than for the households alive in 2010. In contrast, in model economy *B1* this comparison is ambiguous, since the households that were alive in 2035 are better off than the households that were alive in 2010 in only approximately half of the age, education and wealth groups that we consider.

We also find that delaying retirement in model economy *B2* brings about large welfare gains for almost every household who was alive in 2035. This is because in that year consumption taxes have been raised in the benchmark model economy, while this is not the case in the reformed model economy. Moreover while the consumption tax rate is approximately 14 percent larger in the benchmark model economy, the average pension is only 7 percent smaller in the reformed model economy.

The old and the young. We find that the welfare gains of delaying retirement in both model economies are decreasing in age until age 60, and that the 60 year-olds are the households who bear the highest welfare losses, or who enjoy the smallest welfare gains, in both model economies for every education and wealth group that we consider. This is because it is the 60 year-olds who are affected the most by the choice between working more or paying the retirement penalties in the reformed economies, and because their pensions are reduced regardless of their choices.

In model economy *B1* the 70 year-olds are the households who bear the smallest welfare costs of delaying retirement. This is because their leisure does not change and they do not have very long to live with their reduced pensions. In model economy *B2* this is also the case amongst the households who were alive in 2035. In contrast, amongst the households who were alive in 2010, it is the 20 or the 30 year olds who benefit the most from delaying retirement. This is because these groups of households are the ones who benefit the most form the reduced taxation that results from the improved sustainability of the reformed pension system.

The non-educated and the educated. In both model economies we find that, with the exception of the 70 year old college households, the households who have completed only high school are the ones who bear the largest welfare costs of the reform, or who enjoy the smaller welfare gains. This is because minimum pensions buffer the reduction in the pensions of no-high school households, and because in general the reduction in pensions is comparatively smaller for college households than for no-high school households.

The poor and the wealthy. In model economy B2 the wealthy households, and especially those who are alive in 2035 benefit more from the reforms than their wealth-poor colleagues. This is because, while in the benchmark model economy consumption taxes have to be raised sizably in 2033 when the pension fund runs out, in the reformed model economy consumption taxes do not have to be raised for this reason until 2060, and it turns out that this effect outweighs by far the costs imposed by the reform on the wealthy. In contrast, in model economy B1 the consequences of delaying retirement for the poor and the wealthy are far more ambiguous. In the case of college households, fo instance, for both years and every age group except for the 60 year-olds alive in 2010, it turns our that the welfare costs of delaying retirement are smallest for the poorest households. This is because most of these households receive the minimum pensions, which are not changed by the reform and, consequently, their leisure changes by little since they choose to retire when they reach the first retirement age. In contrast, the wealthy households have to suffer the reduction in the real interest rate brought about by the reform, in addition to the reduced leisure and reduced pensions.

8 Concluding comments

We find that delaying the first and the normal retirement ages by three years is sufficient to solve the severe viability problems that plague the current Spanish pension system. Moreover, under the assumption that consumption taxes have to be raised to finance the pension system deficits after the pension fund is exhausted, we find that this reform improves social welfare after the year 2021. We conclude that policymakers should seriously consider reforming the Spanish public pension system along these lines sometime in the near future. Complementary support programs should be enacted for the households with some high school education and for those in the 60-70 age cohort to compensate them for the welfare costs that they suffer during the years immediately after the reform.

References

[1] Arjona R., (2000). On the fiscal balance of the Spanish social security system. *Estudios de Economía Española*, no. 78. FEDEA, Madrid.

[2] Balmaseda M., A. Melguizo, and D. Taguas, (2006). Las reformas necesarias en el sistema de pensiones contributivas en España. *Moneda y Crédito, 222*, 313-340.

[3] Blöndal S., and S. Scarpetta, (1997). The retirement decision in OECD countries. OECD working paper no. 202.

[4] Boldrin M., and S. Jiménez-Martín, (2003). Evaluating Spanish pension expenditure under alternative reform scenarios, DEE WP 652.

[5] Boldrin M., S. Jiménez-Martín, and F. Peracchi, (1999). Social security and retirement in Spain, in J. Gruber and D. Wise (eds.), *Social security and retirement around the world*, 437–473. University of Chicago Press.

[6] Budría S., and J. Díaz-Giménez, (2006a). Economic inequality in Spain: the European Community Household Panel Dataset. *Spanish Economic Review*. Forthcoming.

[7] Budría S., and J. Díaz-Giménez, (2006b). Earnings, income and wealth inequality in Spain: La Encuesta Financiera de las Familias Españolas (EFF). Mimeo.

[8] Castañeda A., J. Díaz-Giménez and J. V. Ríos-Rull (2003). Accounting for the U.S. earnings and wealth inequality. *Journal of Political Economy 4*, 818–855.

[9] Conde-Ruiz J., and V. Galasso, (2003). Early retirement. *Review of Economic Dynamics 6*, 12–36.

[10] Conesa J., and D. Krueger, (1999). Social security with heterogeneous agents. *Review of Economic Dynamics 2*, 757–795.

[11] Cubeddu L., (1998). The intergenerational redistributive effects of unfounded pension programs. International Monetary Fund Working Paper no. 98/180.

[12] Da-Rocha J.M., and F. Lores, (2005). ? Es urgente reformar la seguridad social?. Universidad de Vigo, RGEA WP 5-05.

[13] De Miguel C., and M. Montero, (2004). Envejecimiento y sostenibilidad del sistema de pensiones. Estudios de Economía Española no. 190. FEDEA, Madrid.

[14] De Nardi M., S. İmrohoroğlu, and T. Sargent, (1999). Projected US demographic and social security. *Review of Economic Dynamics* 2, 575–615.

[15] Díaz-Giménez J., and J. Díaz-Saavedra, (2006a). The demographic and educational transitions and the sustainability of the Spanish Pension System. *Moneda y Crédito 222*, 223–270.

[16] Díaz-Giménez J., and J. Díaz-Saavedra, (2006b). Sustaining the Spanish Public Pension System through immigration. Mimeo.

[17] Díaz-Giménez J., V. Quadrini, and J. V. Ríos-Rull, (1997). Dimensions of inequality: facts on the U.S. distributions of earnings, income, and wealth. *Federal Reserve Bank of Minneapolis Quarterly Review* 21, 3–21.

[18] Hubbard G., and K. Judd, (1987). Social security and individual welfare: precautionary saving, borrowing constraints, and the payroll tax. *American Economic Review* 77, 630–646.

[19] Huggett M., and G. Ventura, (1999). On the distributional effects of social security reform. *Review of Economic Dynamics* 2, 498–531.

[20] İmrohoroğlu A., S. İmrohoroğlu, and D. Joines, (1995). A life cycle analysis of social security. *Economic Theory* 6, 83–114.

[21] Jiménez-Martín S. and A. Sánchez-Martín, (2003). An evaluation of the life-cycle effects of minimum pensions on retirement behavior. *Economics Working Papers 715, Department of Economics and Business, Universitat Pompeu Fabra.*

[22] Jiménez-Martín S., (2006). Evaluating the labor supply effects of alternative reforms of the Spanish Pension System. *Moneda y Crédito 222*, 271-312.

[23] Jimeno J., J. Rojas, and S. Puente, (2006). Modelling the impact of aging in Social Security expenditures. Bank of Spain, Documento ocasional 0601.

[24] Meseguer J., (2001). Tendencias de largo plazo del sistema educativo Español y los efectos del envejecimiento. FEDEA. Mimeo.

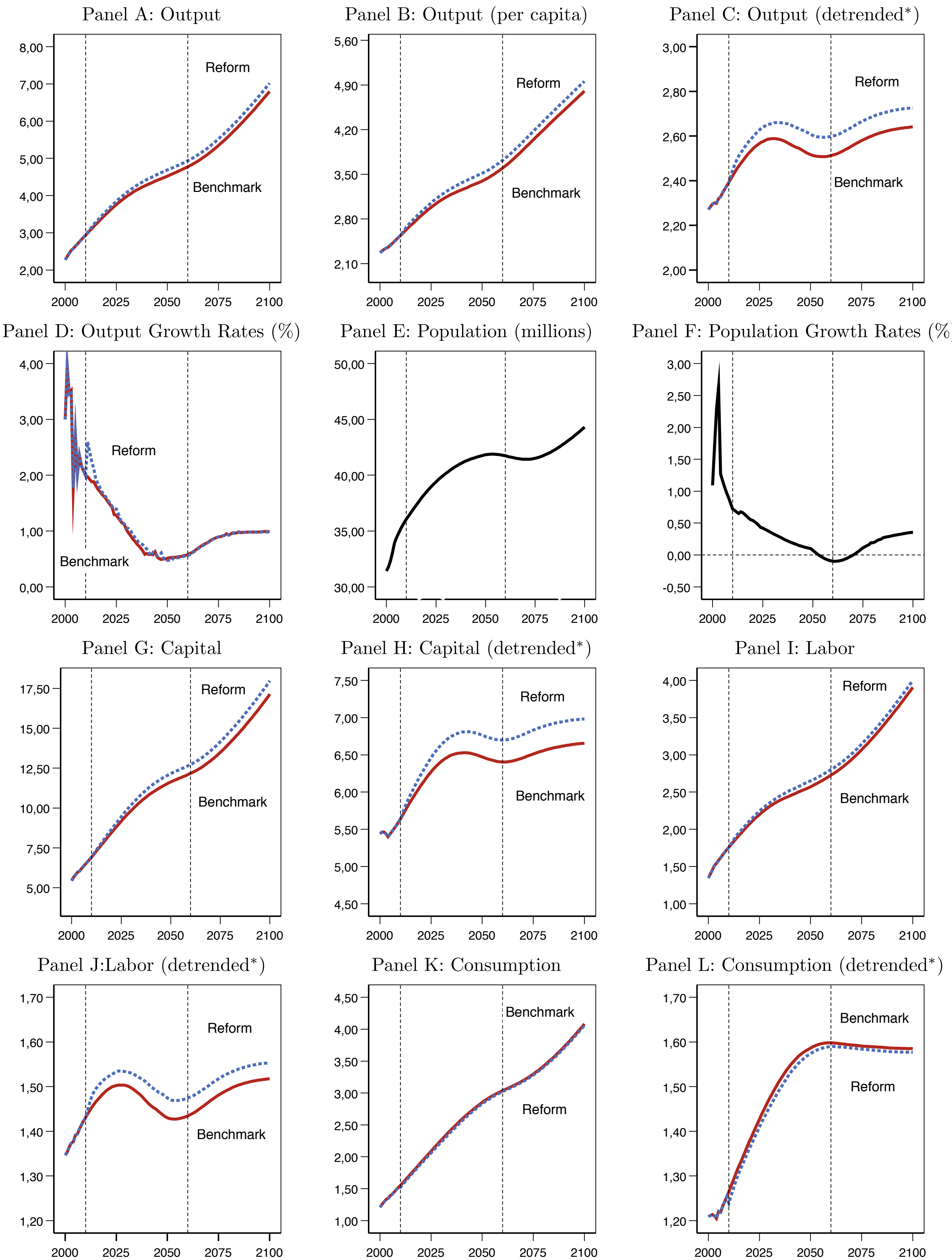
[25] Rojas J., (2005). Life-cycle earnings, cohort size effects and social security: a quantitative exploration. *Journal of Public Economics 89*, 465–485.

[26] Rust J., and C. Phelan, (1997). How social security and medicare affect retirement behavior in a world of incomplete markets. *Econometrica* 65, 781–831.

[27] Sánchez-Martín A., (2003). Endogenous retirement and public pension system reform in Spain. CEMFI, Madrid. Mimeo.

[28] Zabalza A., (1996). La recesión de los noventa en la perspectiva de los últimos treinta años de crecimiento. *Moneda y Crédito* 202, 11–64.

Figure 5: Miscellaneous Time Series (1)



*The time series have been detrended dividing the aggregates by $A_t N_t$.

Figure 6: Miscellaneous Time Series (2)

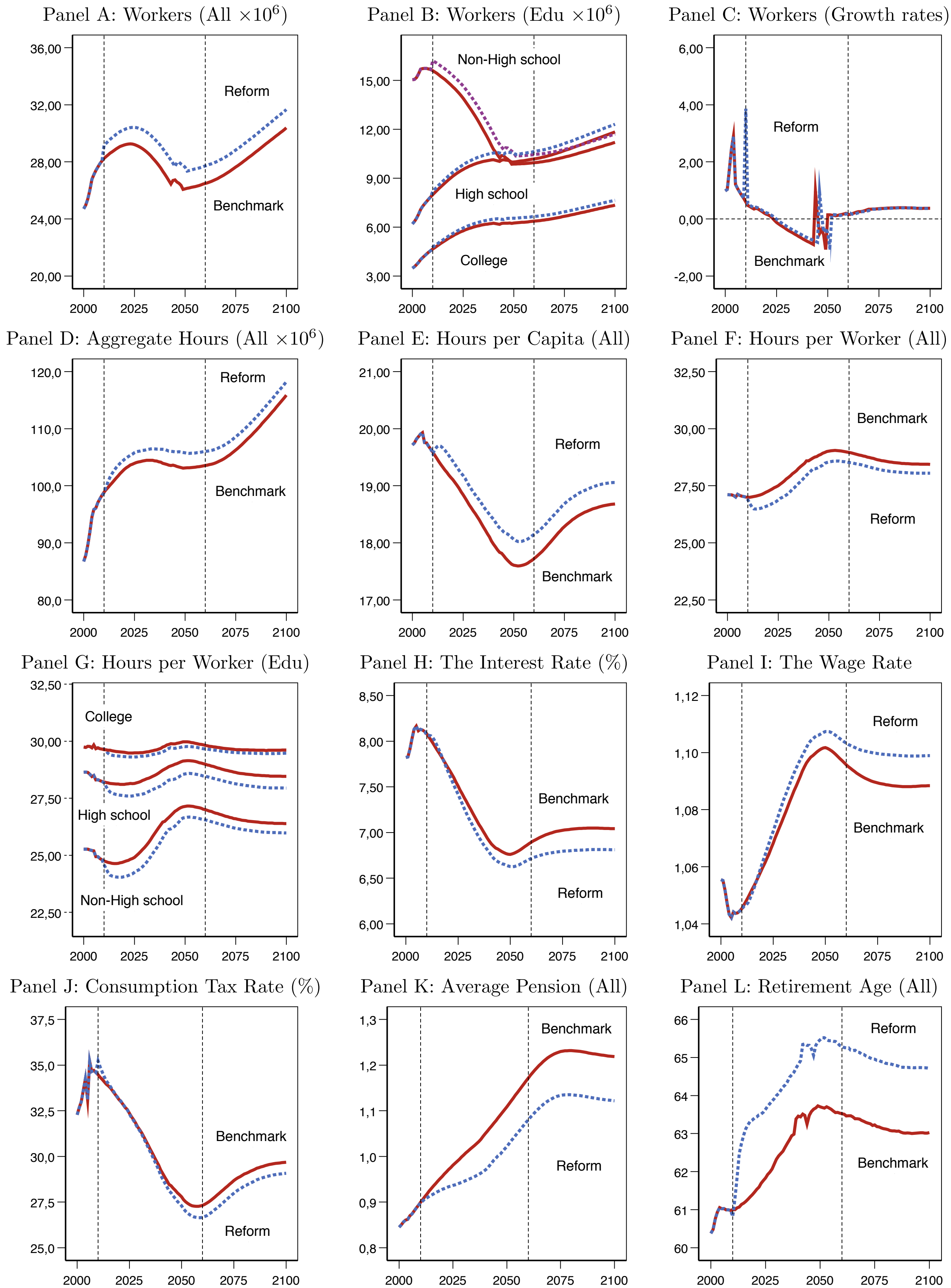
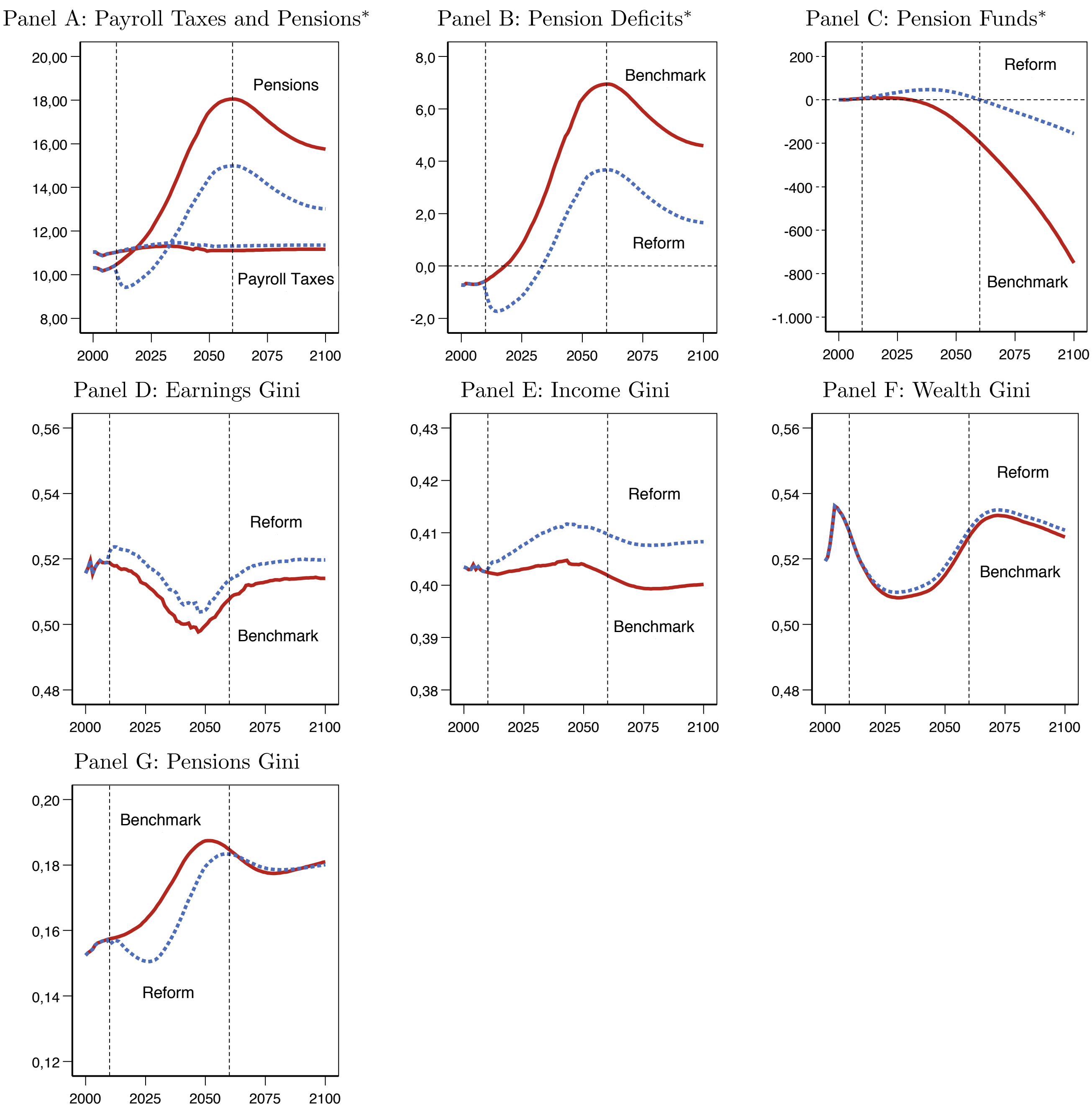


Figure 7: Miscellaneous Time Series (and 3)



*Expressed as a percentage share of output.