Parametric Reforms of the Spanish Pension System: A Quantitative Analysis*

Javier Díaz-Giménez
IESE Business School
<jdiaz@iese.edu>

Julián Díaz-Saavedra
Universidad de Granada
<julianalbertodiaz@ugr.es>

April 12, 2011

Very Preliminary and Incomplete Draft

Please Do Not Quote

Abstract

This paper analyzes the Government's proposal for the reform of the Spanish pension system. This proposal, formally presented to the European Commission in early 2010, increase the statutory retirement ages by two years and increase the number of years of labor income used for pension calculation by 10 years (from the last 15 to the last 25 years before retirement). We use an overlapping generations model economy calibrated to the Spanish economy, with endogenous retirement. We find that the proposed reform reduces retirement pensions and the effective dependency ratio. Consequently, this reform postpones both the initial pension deficit and pension fund depletion by 9 and 10 years, and reduces by over 9 percentage points the VAT rate required to finance the correspondingly lower pension deficit in 2050. The reform also increases the Spanish GDP. Finally, and unlike previous research, we find that this type of reform increases the welfare of the majority of households alive at present.

Keywords: Computable general equilibrium, social security reform, retirement
JEL classification: C68, H55, J26

*We thank Juan Carlos Conesa for an early version of the code. We also gratefully aknowledge the financial support of the Spanish Ministerio de Ciencia y Tecnología (ECO2008-04073).

Table 1: Parametric Pension Reforms in the Literature

	Increasing the Averaging Period						
	Avging Period[a]	Delay Deficit[b]	Delay Fund[c]	The Reformed Pension System in 2050			
				∇Avg P[d]	∇Outlays[e]	∇Deficit[f]	∇Fund[g]
Jimeno (2003)	30	NR[h]	NM[i]	16.6	NR	NR	NM
Da Rocha and Lores (2005)	30	8*	7	14.3	3.7	4.4*	95.7
Sánchez-Martín (2010)	40	10*	NM	15-25	NR	5.7	NM
D-G and D-S (2011)	25	1	3	9	1.3	1.5	NM
	Delaying Retirement						
	Ret Delay[j]						
Da Rocha and Lores (2005)	5	14*	18	7.2*	6.4	7.1*	199.6
D-G and D-S (2009)	3	10	15	6.6	2.3	2.6	79.9
Sánchez-Martín (2010)	2	6*	NM[h]	NR[i]	NR	2.1	NM
D-G and D-S (2011)	2	4	7	4.1	1.7	2.0	NM

[a]Number of years of contributions that are used to calculate the pensions when the reform is complete.
[b]Number of years of delay in the first deficit when compared with the benchmark model economy.
[c]Number of years of delay in the depletion of the pension reserve fund when compared with the benchmark model economy.
[d]Percentage reduction in the average pension with the reform.
[e]Number of percentage points by which the total pension expenditures to GDP ratio is reduced with the reform.
[f]Number of percentage points by which the total deficit to GDP ratio is reduced with the reform.
[g]Number of percentage points by which the pension system debt to GDP ratio is reduced with the reform.
[h]NR means that this number was not reported.
[i]NM means that this feature of the model economy was not modeled.
[j]Number of years of delay in the retirement ages when the reform is complete.
*This means that we calculated the statistic from one of the graphs included in the paper using a ruler

Table 2: The Three Parametric Pension Reforms in This Article

	Delay Deficit[a]	Delay Fund[b]	The Reformed Pension System in 2050			
			∇Avg P[c]	∇Outlays[d]	∇Deficit[e]	$\nabla\tau_c^f$
Increasing the Averaging Period	1	3	9	1.3	1.5	2.8
Delaying Retirement	4	7	4.1	1.7	2.0	7.0
Both Reforms	9	10	11.8	2.8	3.2	9.1

[a]Number of years of delay in the first deficit when compared with the benchmark model economy.
[b]Number of years of delay in the depletion of the pension reserve fund when compared with the benchmark model economy.
[c]Percentage reduction in the average pension with the reform.
[d]Number of percentage points by which the total pension expenditures to GDP ratio is reduced with the reform.
[e]Number of percentage points by which the total deficit to GDP ratio is reduced with the reform.
[f]Number of percentage points by which the consumption tax rate is reduced with the reform.

1 Introduction

It is well known that the current Spanish public pension system will collapse at some point after 2020. Consequently, several international organisms and researchers have proposed different parametric reforms of this system to guarantee its future sustainability. Most of these reforms involve reducing pension generosity and increasing the statutory retirement ages. The intuition is that these parametric changes will reduce future pension payments.

Consequently, at the end of January 2010 the Spanish Government sent to the European Commission its *Stability Plan 2009-2013*, which, and among other measures, proposed a reform of the pension system, based on two principal parametric changes. Firstly, a gradual increase in the number of years used to compute the retirement pension, starting in 2013. At present, the regulatory base, which is the principal component of the retirement pension, is computed as average labor earnings during the last 15 years before retirement. The reform would increase this averaging period, so that the regulatory base becomes average labor income during the 25 years prior to retirement. Secondly, an increase of two years in the statutory retirement ages. This change would also be implemented gradually, raising these retirement ages by two months per year, starting in 2013. Consequently, 62 and 67 would be the first and normal retirement ages in 2025, instead of 60 and 65 years as at present.

The Spanish government states that this reform will produce a significant improvement of the sustainability of the public pension system. According to the government's estimates, the first parametric change will reduce pension payments in two points of GDP. And an increase of two years in the statutory retirement ages will also reduce pension payments in other two points of GDP. Then, the proposed reform is aimed to reduce the long run pension payments-GDP ratio in almost 4 percentage points[1].

The present paper analyzes the consequences of this reform for the sustainability of the Spanish pension system, for the aggregates, and for the well being of current and future cohorts. Various previous research papers have analyzed the consequences of implementing reforms similar to the currently proposed by the Government. The following section summarizes their main findings and explains the distinctive aspects of our paper, with regard to the methodology chosen, technical factors and the scope of the reforms explored.

To this thing, we use a model economy which resembles the model described in Díaz-Giménez and Díaz-Saavedra (2009). Specifically, we use a multiperiod, general equilibrium, overlapping generations model economy populated by heterogeneous households. In this model economy, households differ exogenously in their place of birth, age and education, and endogenously in their employment status, wealth and pension entitlements. They receive a stochastic endowment of efficiency labor units each period, and face disability risks and survival risks. They understand the link between the payroll taxes they pay and the public pensions they receive, decide how much to consume and how much to work, and when to retire from the labor force.

However, the study cited above, calibrated to data for the Spanish economy in 1997, only analyzes a sudden and unexpected increase of three years in the legal retirement ages, from 2010 onwards, in an economy in which the Government can issue the quantity of public debt necessary to finance the future deficits of the Spanish pension system. The present study differs in a series of important aspects. Firstly, our research analyzes a raising of the legal retirement ages by two years, which exactly reflects the Government's proposal. Secondly, we also consider a further increase i.e. the increase (from the final 15 to the final 25 years prior to retirement) in the number of years of labor income used to calculate the regulatory base. Not only is this the proposal of the Government, it is a common recommendation of international organisms and researchers, to reduce the future disequilibrium of the system. Thirdly, the implementation of the parametric changes is gradual, once again as the Government advocates. This hypothesis is important, as it implicitly reflects the inviability, from the political point of view, of a significant and abrupt change in pensions economic policy. Since pension systems are programs of protection against contingencies over the life cycle, modifications to them must be made very gradually in order not to seriously penalize households who have taken irreversible decisions with regard to their saving patterns and their labor supply. Fourthly, our study assumes that once the Reserve Fund has been exhausted, pension system deficits will be financed by increasing the value added tax rate, instead

[1]Plan de Estabilidad 2009-2013, page 42.

of allowing that the government get into debt indefinitely. This is important, because this assumption avoids giving the government an unrealistic free lunch. Fifthly, to simulate the Spanish population aging, our study introduces the last projection for the population realized by the Spanish *Instituto Nacional de Estadística* (INE). This is important because this projection predicts a more pesimistic demographic scenario during the next decades, in comparisson to previous projections. Consequently, in this paper we should find both, that the first pension deficit and the Pension Fund depletion are brought forward, and that the pension system imbalance is bigger during the next decades, in comparisson to our previuos study.

We simulate this reform and we find that our results are less optimistic than those projected by the Spanish Government. Specifically, we continue to find that this reform reduces the long-run expenditure on pensions, since it reduces retirement pensions by over 11 percent and increases the average retirement age by 1.1 years. However, after the reform the pension payments fall by almost 3 points of GDP in 2050, from 19.3 to 16.5 percent. This implies that the VAT rate required to finance the pension system imbalance falls from 38 to 29 percent in that same year. Moreover, the reform delays the first pension deficit by 9 years and depletion of the Pension Fund by 10 years. Specifically, while under current pension rules the first pension deficit appears in 2015 and fund depletion in 2025, under the reform these are postponed to 2024 and 2035 respectively.

We also find that the reform is expansionary. Specifically, it increases the GDP by 3.1 percent in 2050, due to both greater physical capital and the increase in the number of hours worked. Capital increases because of lower pensions, and the number of hours worked increases because of the higher average retirement age. With regard to aggregate consumption, we find that it increases by over 3.1 percent that same year. This is because lower VAT compensates for lower retirement pensions.

Finally, we analyze the welfare consequences of this reform. Specifically, we determine whether lower pensions and less leisure are compensated for by lower taxation in the long run. Unlike previous research papers, we find that this type of reform increases the well being of most of the households alive at the time of the policy announce. And this is because two reasons. Firstly, and despite lower pensions and decreased leisure, most households benefit overall, due to the lower VAT rate in the long run. And secondly, because the gradual introduction of these parametric changes also gives households valuable time to modify their work and saving decisions before the new measures come into force.

However, this is not the case for certain households aged 45-55, since these bear the brunt of the reform. Within this age group, we find that the reform increases welfare for college graduate workers. Although their pensions are lower, they are not significantly affected by the increase in the statutory retirement ages, since such households already choose to retire later than others. On the other hand, and surprisingly, we find that the workers most negatively affected are not unskilled workers, but instead those with an intermediate educational level, for two reasons. Firstly, because the reduction in retirement pensions is greater for high school workers. Secondly, despite the retirement age increases more for high school dropouts, the total number of additional hours worked under the reform increases more for high school workers, as they devote more time to labor market activities.

In conclusion, we find that the Government's proposal to reform the Spanish pension system is a good first step to improve its long-run sustainability. Furthermore, we find that the reform enhances welfare for most households alive at present.

2 Previous literature

Various previous research papers have studied the consequences of parametric reforms aimed at improving the long-run sustainability of the Spanish pension system. Based on differing methodologies, such work has analyzed two principal reforms: increasing the number of years used for pension calculation and/or postponing the normal retirement age.

Concerning the first of these, Sánchez-Martín (2010) [2], uses an overlapping generations model economy

[2]The principal differences between Sanchez-Martin's article and ours are that he does not endogenize the labour decision,

to study the consequences of abruptly increasing the number of years used for pension calculation from the final 15 to the final 40 years before retirement (rather than the final 25 years as the Government proposes). He finds that retirement pensions decrease by 10 percent and pension expenditures are reduced by 1.8 percentage points of output in 2050, and thus the pension deficit is also reduced from 8.7 to 6.9 percent of output in that same year. Regarding the welfare consequences, he also finds that most of the medium and high educated workers alive at the moment of this reform, face welfare losses. Jimeno (2003) and Da Rocha and Lores (2005) use an individual life cycle profiles approach to study the consequences of abruptly increasing the number of years used for pension calculation, from the last 15 to the last 30 before retirement. The former finds that the average pension decreases by approximately 10 percent under such reform, and consequently, pension expenditures are reduced from 19.6 to 17.7 percent of output in 2050. The latter find that by that same year, pension expenditures are reduced by approximately 10 percent, from 25.4 to 22.7 percent of output.

Díaz-Giménez and Díaz-Saavedra (2009), study the consequences of abruptly raising the current statutory retirement ages. They find that an increase of three years postpones the effective retirement age by 1.7 years, the first pension deficit by 14 years and pension fund depletion by 23 years. Sánchez-Martin (2010) study the consequences of abruptly raising in tow years the current normal retirement age, and he finds that this reform increases the effective retirement age by 1.5 years. Then, this reform reduces the pension deficit from 8.7 of output to 5.3 percent in 2050. Da Rocha and Lores (2005) study the consequences of gradually postponing, from 2005 onwards, the normal retirement age by five years, from the current 65 to 70. They find that by 2050 this reform reduces the accumulated pension debt from 259 to 50 percent of GDP. Finally, the first two papers also studied the welfare changes brought by this reform and they find that most of the cohorts alive at moment of this policy change face welfare losses.

Certain aspects of the research cited above are, however, unsatisfactory. Firstly, the individual life cycle profiles approach cannot take into account the fact that any reform which changes the marginal utility of working will affect the average retirement age and the sustainability of the public pension system, and consequently, the results such research offers. For example, the increase in the effective retirement age could be lower than the increase in the statutory retirement ages. Thus, we consider that a dynamic general equilibrium model with endogenous retirement is more suitable to evaluate the consequences of this type of pension reform. To date, however, research employing this latter methodology has not considered the reform currently proposed by the Government, since at least one of the following factors differs: the magnitude of the increase resulting from the change in policy, the implementation of the two parametric changes separately, or the introduction of the reform abruptly. Furthermore, we consider that any analysis of the sustainability of the Spanish pension system should consider the existence of the Spanish Pension Fund, as this could finance pension deficits for several years before the Spanish Government is forced to increase tax rates. Then, these are the reasons why we analyze the present Government's proposal for pension system reform using a general equilibrium model economy.

3 The Model Economy

Our model economy is an overlapping generations model economy. We assume that it is populated by a continuum of heterogeneous households, a representative firm, and a government. We normalize the continuum of households each period so that its measure is always one. And we describe these three sectors below.

3.1 Households

The households differ in their education, $h \in H$; in their age, $j \in J$; in their employment status, $e \in \mathcal{E}$; in their assets, $a \in A$; in their pension rights, $b \in B$, and in their pensions $p_t \in P_{rt} \cup P_{dt}$. Sets H, J, $\mathcal{E}$, A, B, P_{rt} and P_{dt} are all finite sets and we describe them below. We use $\mu_{h,j,e,a,b,p,t}$ to denote the

that his households do not face an idiosyncratic labour productivity shock, and he abstracts from educational transition and from many details of the Spanish tax and public pension systems, such us the pension fund, maximum pensions, and disability pensions.

measure of households of type (h, j, e, a, b, p) at period t. For convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript.

Education. We abstract from the education decision, and we assume that the education of every household is determined forever when they enter the economy. We consider three educational levels. Consequently, $H = \{1, 2, 3\}$. Educational level $h = 1$ denotes that the household has dropped out of high school.[3] Educational level $h = 2$ denotes that the household has completed high school but has not completed college. And educational level $h=3$ denotes that the household has completed college.

Age. Every household enters the economy when it is 20 years old and it is forced to exit the economy at age 100. Consequently, $J = \{20, 21, \ldots, 100\}$.

Population dynamics. Each period a measure f_{hjt} of households enters the economy. This measure of households is exogenous and we use it to model the demographic scenario. We use measure f_{hjt} to represent the flows of both newborns and migrants.

We assume that each period the households face a conditional probability of surviving from age j to age $j+1$, which we denote by ψ_{jt}. This probability depends on the age of the household and it varies with time, but it does not depend on the educational level.

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, and we compute it as follows:

$$n_t = \sum_H \sum_J f_{h,j,t} + \sum_J \psi_{j,t-1} \sum_H \mu_{h,j,t-1} - 1. \tag{1}$$

Every period we normalize the measure of households so that the law of motion of μ_{jt} is

$$\mu_{20,t+1} = \frac{1}{(1 + n_{t+1})} f_{20,t+1}, \text{ for } j = 20 \text{ and} \tag{2}$$

$$\mu_{j,t+1} = \frac{1}{(1 + n_{t+1})} \Big[f_{j,t+1} + \psi_{j-1,t} \mu_{j-1,t} \Big], \text{ for each } j > 20. \tag{3}$$

Employment status. Households in our economy are either workers, disabled households, or retirees. We denote workers by ω, disabled households by d and retirees by ρ. Consequently, $\mathcal{E} = \{\omega, d, \rho\}$. Every household enters the economy as a worker. Each period of their working lives the workers face a positive probability of becoming disabled, and after they reach the first retirement age, which we denote by R_0, they decide whether to retire. We assume that both the disability shock and the retirement decision are irreversible. And we also assume that in our model economy there is no mandatory retirement age.

Workers. Workers receive an endowment of efficiency labor units every period. This endowment has two components: a deterministic component, which we denote by ϵ_{hj}, and a stochastic idiosyncratic component, which we denote by s.

We use the deterministic component to characterize the life-cycle profile of earnings. This profile is different for each educational group, and we model it using quadratic functions on age of the following form:

$$\epsilon_{hj} = a_{1h} + a_{2h} j - a_{3h} j^2 \tag{4}$$

[3]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.*

We choose this functional forms because they allow us to represent the life-cycle profiles of the productivity of workers in a very parsimonious way. We represent the calibrated versions of these functions in Panel A of Figure 1.

We use the stochastic component to generate earnings and wealth inequality within the age cohorts. We assume that s is independent and identically distributed across the households, that it does not depend on the education level, and that it follows a first order, finite state Markov chain with conditional transition probabilities given by

$$\Gamma[s' \mid s] = \Pr\{s_{t+1} = s' \mid s_t = s\}, \text{ where } s, s' \in \omega = \{s_1, s_1, \dots, s_n\}. \tag{5}$$

We assume that the process on s takes three values and, consequently, $s \in \{s_1, s_2, s_3\}$. We make this assumption 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 sufficient detail, and because we want to keep this process as parsimonious as possible.

Disabled households. We assume that a worker of education level h and age j faces a probability φ_{hj} of becoming disabled from age $j+1$ onwards. The workers find out whether they have become disabled at the end of the period, once they have made their labor and consumption decisions. When a worker becomes disabled, it exits the labor market and it receives no further endowments of efficiency labor units, but she is entitled to receive a disability pension. When a disabled worker reaches the first retirement age, R_0, she decides whether to keep its disability pension, or to exchange it for a retirement pension.

To determine the values of the probabilities of the φ_{hj}, we proceed in two stages. First we model the aggregate probability of becoming disabled. We denote by q_j, and we assume that it is determined by the following function:

$$q_j = a_9 e^{(a_{10} \times j)} \tag{6}$$

We choose this functional form because, according to the *Boletín de Estadísticas Laborales* (2007), the number of disabled people in Spain increases more than proportionally with age.

Once we know the value of q_j we solve the following system of equations:

$$\left\{ \begin{array}{lcl} q_j \mu_{j,2007} & = & \sum_h \varphi_{hj} \mu_{hj,2007} \\ \varphi_{2j} & = & a_{11} \varphi_{1j} \\ \varphi_{3j} & = & a_{12} \varphi_{1j} \end{array} \right. \tag{7}$$

This procedure allows us to make the disability process dependent on the educational level as is the case in Spain. We represent our calibrated values for φ_{hj} in Panel C of Figure 1.[4]

Retirees. Workers of age R_0 or older observe their endowment of efficiency labor units and they decide whether remain in the labor force that period, or whether to retire and start collecting their retirement pension. Naturally, retirees receive no endowments of efficiency labor units.

Assets. We assume that the households in our model economy cannot borrow. Since leisure is an argument of their 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 assets, which we denote by a_t, and which take the form of productive capital. For computational reasons we restrict the asset holdings to belong to the discrete set $\mathcal{A} = \{a_0, a_1, \dots, a_n\}$. We choose $n = 49$, and assume that $a_0 = 0$, that $a_{49} = 200$, and that the spacing between points in set $\mathcal{A}$ is increasing.[5]

[4] The data on disability can be found at www.mtas.es/estadisticas.

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

Pension Rights. We assume that the workers' pension rights belong to the discrete set $B=\{b_0, b_1, \ldots, b_m\}$. The b_i record the workers' average labor income during the N_b years previous to the first retirement age, R_0. We assume that $b_0 = 0$, that $b_m = 9.01$, that $m = 9$, and that the grid on B is equally spaced. Our computational procedure verifies that the value of the upper bound, b_m, is higher than the value of the maximum covered earnings in every period.

Pensions. We assume that the reitrement pensions belong to set $P_{rt}=\{p_{r0t}, p_{r1t}, \ldots, p_{rmt}\}$ and that the disability pensions belong to set $P_{dt}=\{p_{d0t}, p_{d1t}, \ldots, p_{dmt}\}$. The rules of the pension system determine the mapping from pension rights into pensions, and workers take into account this mapping when they decide how much to work and when to retire. Since this mapping is single valued, $m = 9$ for both P_{rt} and P_{dt}. Finally, we assume that the distances between any two consecutive points in both pensions sets are increasing. This is because minimum pensions play a large role in the Spanish system and this suggests that we should have a tight grid in the low end of set P_{rt}.

Market Arrangements. We assume that there are no insurance markets for the stochastic component of the endowment shock. This is a key feature of our model economy. When insurance markets are allowed to operate, every household of the same age and education level is identical, and the earnings and wealth inequality almost disappears.

The Households' Decision Problem. We assume that the households in our model economy have identical Cobb-Douglas preferences defined over pairs of consumption and non-market time, and that they solve the following decision problem:

$$\max E \left\{ \sum_{j=20}^{100} \beta^{j-20}\, \psi_{jt}\, [c_{hjt}^{\alpha}(1-l_{hjt})^{(1-\alpha)}]^{(1-\sigma)}/1-\sigma \right\} \tag{8}$$

subject to

$$c_{hjt} + a_{hjt+1} + \tau_{hjt} = (1+r_t)\, a_{hjt} + y_{hjt}\, \mathcal{I}_{\omega t} + p_{dt}\, \mathcal{I}_{dt} + p_{rt}\, \mathcal{I}_{\rho t} + z_t \tag{9}$$

to

$$\tau_{hjt} = \tau_{ct}\, c_{hjt} + \tau_{kt}\, r_t\, a_{hjt} + \tau_{lt}[y_{hjt} - \tau_{st}(y_{hjt})\, \mathcal{I}_{jt\leq R_1}] + \tau_{st}(y_{hjt})\, \mathcal{I}_{jt\leq R_1} \tag{10}$$

and to

$$y_{hjt} = w_t\, \epsilon_{hj}\, s_t\, l_{hjt} \tag{11}$$

where $a_{hjt} \in \mathcal{A}$, $p_{rt} \in P_{rt}$, $p_{dt} \in P_{dt}$ for all t, and a_{hj0} is given. Parameter $\beta > 0$ denotes the time discount factor, c_{hjt} denotes consumption, l_{hjt} denotes labor, a_{hjt+1} denotes the end-of-period assets, τ_{hjt} denotes total tax payments, r_t is the rate of return on capital gross of all taxes, y_{hjt} is labor income, p_{rt} is the retirement pension, p_{dt} is the disability pension, z_t denotes the non-pension transfers, and the functions $\mathcal{I}_{\omega t}$, $\mathcal{I}_{dt}$, $\mathcal{I}_{\rho t}$, indicate whether the household is a worker, a disabled household, or a retiree during period t.[6] In Expression (10), τ_{ct} denotes the consumption tax rate, τ_{kt} the capital income tax rate, τ_{lt} the labor income tax rate, $\tau_{st}(y_{hjt})$ the payroll tax function, R_1 is the normal retirement age and indicator function, $\mathcal{I}_{jt\leq R_1}$ indicates whether the worker is R_1 years old or younger.[7] Finally, in Expression (11), w_t denotes the wage rate per efficiency labor unit gross of all taxes.

3.2 The Representative Firm

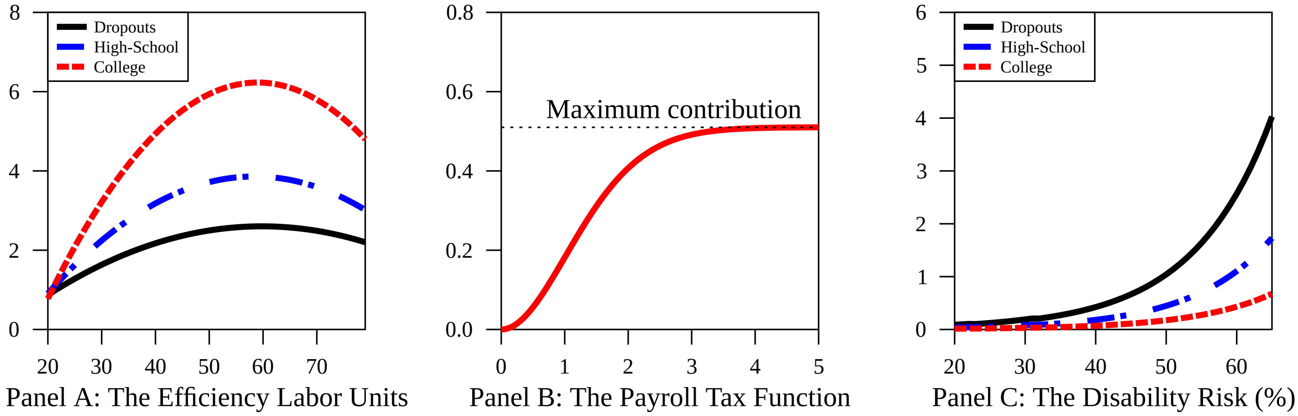
We assume that there is a stand-in firm with the following Cobb-Douglas production function

$$Y_t = K_t^{\theta}\, (A_t L_t)^{1-\theta} \tag{12}$$

[6] Recall that workers decide whether to retire after they observe their endowment shock s.

[7] In 2002 the Spanish public pension system was reformed and workers older than R_1 years were exempted from paying payroll taxes. We use indicator function $\mathcal{I}_{jt\leq R_1}$ to replicate this feature of the Spanish pension system in our model economy.

Figure 1: The Endowment of Efficiency Labor Units, the Payroll Tax, and the Disability Risk



where K_t is the stock of capital, L_t is the total number of efficiency units of labor hired by the firm, and A_t denotes an exogenous labor-augmenting productivity factor whose law of motion is $A_{t+1} = (1+\gamma_t)\,A_t$, and where $A_0 > 0$. In our model economy there are three exogenous sources of growth. The technological process which we have just discussed, the growth of the population, and the increases in education. Although these last two variables play the same role in our model economy, we keep them separate for measurement reasons.

Finally, we assume that the representative firm behaves competitively both in the factor and in the product markets, and that it maximizes profits. These assumptions imply that the first order conditions of the firm's decision problem are described in the following two expressions

$$r_t = \theta\left(\frac{K_t}{A_t L_t}\right)^{\theta-1} - \delta \tag{13}$$

$$w_t = (1-\theta)\left(\frac{K_t}{A_t L_t}\right)^{\theta} \tag{14}$$

where $0 < \delta < 1$ is the depreciation rate of the stock of capital.

3.3 The Government

The government taxes consumption, capital income, and labor income. It uses its tax revenues to consume and to make transfers to households, and it runs a pay-as-you-go pension system. In this model economy the government budget constraint is

$$G_t + Z_t = T_{ct} + T_{kt} + T_{lt} + E_t \tag{15}$$

where G_t denotes government consumption, Z_t denotes transfers other than pensions, T_{ct}, T_{kt}, and T_{lt}, denote the revenues collected by the consumption tax, the capital income tax, and the labor income tax, and E_t denotes the unintentional bequests of deceased households.

We assume that pension surpluses and deficits are accumulated in a pension reserve fund which evolves according to

$$F_{t+1} = (1+r^*)F_t + T_{st} - P_t \tag{16}$$

where F_t denotes the value of the fund at the beginning of period t, r^* is the exogenous rate of return of the fund's assets, T_{st} denotes the revenues collected by the payroll tax, and P_t denotes total pension payments. In this article we assume that when the pension reserve fund runs out the government changes the consumption tax rate as needed in order to satisfy its budget.

Payroll taxes. In Spain the payroll tax is capped and it has a tax-exempt minimum. In our model economy the payroll tax function is the following:

$$\tau_{st}(y_{hjt}) = a_4\bar{y}_t - \left[a_4\bar{y}_t \left(1 + \frac{a_5 y_{hjt}}{a_4\bar{y}_t}\right)^{-y_{hjt}/a_4\bar{y}_t} \right] \tag{17}$$

Parameter a_4 is the cap of the payroll tax and $\bar{y}_t$ is per capita income at period t. This function allows us to replicate the Spanish payroll tax cap, but it does not allow us to replicate the tax exempt minimum. In Panel B of Figure 1 we represent the payroll tax function for our calibrated values of a_4 and a_5 for 2008.

Retirement pensions. A household of age $j \geq R_0$ who chooses to retire, receives a retirement pension which is calculated according to by the following formula, which replicates the main features of Spanish retirement pensions:

$$p_{rt} = \frac{1}{N_b}\phi(1.02)^v(1-\lambda_j)\sum_{t=j-N_b}^{j-1}\min\{a_6\bar{y}_t, y_{hjt}\} \tag{18}$$

where parameter N_b denotes the number of consecutive years immediately before retirement that are used to compute the retirement pensions. Parameter $0<\phi<1$ denotes the pension system replacement rate. Variable v denotes the number of years that the worker remains in the labor force after reaching the normal retirement age.[8] Function $0\leq\lambda_j<1$ is the early retirement penalty. And $a_6\bar{y}_t$ is the maximum covered earnings. To replicate the Spanish system, we compute our model economy retirement pensions upon retirement and we index them to the rate of growth of output.

We also require that $p_{r0t} \leq p_{rt} \leq p_{rmt}$, where p_{r0t} denotes the minimum retirement pension and p_{rmt} denotes the maximum retirement pension. These limits vary with time because the Spanish minimum and maximum retirement pensions are adjusted to keep up with output.[9]

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

$$\lambda_j = \begin{cases} a_7 - a_8(j-R_0) & \text{if } j < R_1 \\ 0 & \text{if } j \geq R_1 \end{cases} \tag{19}$$

Finally, the Spanish pension replacement rate is a function of the number of years of contributions. In our model economy we abstract from this feature because it requires an additional state variable.[10]

Disability pensions. We model disability pensions explicitly for two reasons: because they represent a large share of all Spanish pensions (10.8 percent of all pensions in 2008), and because in many cases disability pensions are used as an alternative route to early retirement.[11] To replicate the current Spanish rules, we assume that there is a minimum disability pension which coincides with the minimum retirement pension. And that the disability pensions are 75 percent of the households' retirement claims. Formally, we compute the disability pensions as follows:

$$p_{dt} = \max\{p_{r0t}, 0.75p_{rt}\}. \tag{20}$$

[8] This late retirement premium was introduced in the 2002 reform of the Spanish public pension system.

[9] In fact, the Spanish pension is adjusted with the inflation rate and the minimum penson is increased discretionally. This has implied that over the last decade or so the Spanish minimum pension has roughly kept up with per capita GDP, and that the maximum pension has decreased as a share of per capita GDP.

[10] It turns out that this last assumption is irrelevant because the workers in our model economy always choose to supply some labor, and consequently they contribute to the pension system during their entire working lives.

[11] See Boldrin and Jiménez-Martín (2003) for an elaboration of this argument.

We assume that after a disabled household reaches the first retirement age, R_0, it can change its disability pension for a retirement pension paying the early retirement penalty if applicable.[12]

3.4 Definition of equilibrium

Let $h \in H$, $j \in J$, $e \in \mathcal{E}$, $a \in \mathcal{A}$, $b \in B$, and $p_t \in P_{rt} \cup P_{dt}$, and let $\mu_{h,j,e,a,b,p,t}$ be a probability measure defined on $\Re = J \times H \times \mathcal{E} \times \mathcal{A} \times B \times P_{rt} \cup P_{dt}$.[13] Then, given initial conditions μ_0, A_0, E_0, F_0, and K_0, a competitive equilibrium for this economy is a government policy, $\{G_t, P_t, Z_t, T_{ct}, T_{kt}, T_{lt}, T_{st}, E_{t+1}, F_{t+1}\}_{t=0}^{\infty}$, a household policy, $\{c_t(h,j,e,a,b,p),\ l_t(h,j,e,a,b,p),\ a_{t+1}(h,j,e,a,b,p)\}_{t=0}^{\infty}$, 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, $\{Y_t, K_{t+1}, L_t, I_t\}_{t=0}^{\infty}$, a function, Q, and a number, r^*, such that:

(i) Factor inputs, pension payments, transfers, tax revenues, and accidental bequests are obtained aggregating over the model economy households as follows:

$$K_{t+1} = \int a_{hjt+1} d\mu_t \tag{21}$$

$$L_t = \int \epsilon_{hj} s_t l_{hjt} d\mu_t \tag{22}$$

$$P_t = \int (p_{rt} + p_{dt}) d\mu_t \tag{23}$$

$$Z_t = \int z_t d\mu_t \tag{24}$$

$$T_{ct} = \int \tau_{ct} c_{hjt} d\mu_t \tag{25}$$

$$T_{kt} = \int \tau_{kt} r_t a_{hjt} d\mu_t \tag{26}$$

$$T_{lt} = \int \tau_{lt} \left[y_{hjt} - \tau_{st}(y_{hjt})\, I_{j \leq R_1} \right] d\mu_t \tag{27}$$

$$T_{st} = \int \tau_{st}(y_{hjt})\, I_{j \leq R_1}\, d\mu_t \tag{28}$$

$$E_{t+1} = \int (1 - \psi_{jt})(1 + r_{t+1}) a_{hjt+1} d\mu_t \tag{29}$$

where $y_{hjt} = w_t\, \epsilon_{hj}\, s_t\, l_{hjt}$ and all the integrals are defined over the state space $\Re$.

(ii) Given the initial conditions and the government policy, the household policy solves the households' decision problem defined in Expressions (8), (9), (10) and (11).

(iii) Given the initial conditions, the macroeconomic aggregates satisfy Expressions (12) and (32), and the factor prices are the factor marginal productivities defined in Expressions (13) and (14).

(iv) The government policy and r^* satisfy the government budget constraint described in Expression (15), and the law of motion of the pension system fund described in Expression (16).

(v) The goods market clears:

$$\int_{\Re} c_{hjt} d\mu_t + K_{t+1} + G_t + \mathcal{I}_{F \geq 0}(T_{st} - P_t) = F(K_t, A_t L_t) + (1 - \delta) K_t. \tag{30}$$

The last term of the left-hand side of this expression is not standard. The indicator function $\mathcal{I}_{F \geq 0}$ takes value one if the pension fund is not negative at the beginning of period t and 0 otherwise. It states that the pension system surpluses are invested in the pension fund and that the pension

[12] The Spanish rules contemplate a special reduction of the first retirement age for disabled households. The reduction is proportional to the number of years of contributions. We have not included this feature in our model economy for computational reasons.

[13] Recall that, for convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript. We also drop the first subscript whenever there are no differences between immigrants and natives.

deficits are financed using the proceeds of the fund until it is depleted. This term would show up as net exports in the standard national income and product accounts.[14]

If we define net investment I_t as

$$I_t = F(K_t, A_t L_t) - \int_{\Re} c_{hjt} d\mu_t - G_t - \mathcal{I}_{F \geq 0}(T_{st} - P_t) \tag{31}$$

then equation (30) implies the law of motion of aggregate capital is

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{32}$$

(vi) The law of motion for μ_t is:

$$\mu_{t+1} = \int_{\Re} Q_t d\mu_t. \tag{33}$$

Describing function Q formally is complicated because it specifies the transitions of the measure of households along its six dimensions: education level, age, employment status, assets holdings, pension rights, and pensions. An informal description of this function is the following: The evolution of μ_{ht} is implied by the educational shares of new-entrants. The educational shares of twenty-year olds are exogenous, and we assume that the educational shares of older entrants replicate those of the existing population. The evolution of μ_{jt} is described in Expressions (1), (2) and (3). The evolution of μ_{et} is governed by the conditional transition probability matrix of its stochastic component, by the probability of becoming disabled, and by the optimal decision to retire. We assume that the households enter the economy as able workers, and that they draw the stochastic component of their initial endowment of efficiency labor units from its invariant distribution. We also assume that twenty year olds enter the economy with zero assets and that the wealth shares of older entrants replicate those of the existing population. The evolution of μ_{at} is determined by the optimal savings decision. The evolution of μ_{bt} is determined by the rules of the Spanish public pension system which we have described in Section **??**, and again we assume the pension-right shares of the new entrants replicate those of the existing population. Finally, we assume that once a household retires or becomes disabled its disability or retirement pensions never change.

4 Calibration

To calibrate our model economy in general we do the following:

(a) We choose a calibration target country and calibration target year.

(b) We choose the initial conditions and the parameter values that allow our model economy to replicate as closely as possible selected macroeconomic aggregates and ratios, and distributional features of tour chosen country in the target year.

In this article we have chosen Spain as the calibration target country and 2008 as the calibration target year.

4.1 Initial conditions

The initial value of the capital stock implied by the initial distribution of households is $K_{2008} = 9.3754$. This number which corresponds to a capital output ratio of $(K/Y)_{2008} = 3.19$ which is the value for the Spanish economy in 2008.

[14]In the period in which the fund runs out, the government uses up whatever remains of the fund and it raises the consumption tax rate to obtain the revenues needed to finance that period's government pension deficit.

4.2 Parameters

When all is told, to characterize our model economy fully, we must choose the values of a total of 49 parameters. Of these 49 parameters, 3 describe the household preferences, 21 the process on the endowment of efficiency labor units, 4 the disability risk, 3 the production technology, 12 the pension system rules, and 6 the remaining features of the government policy.

To choose the values of these 49 parameters we need an initial distribution of households, μ_0, 49 calibration targets which we describe below.

4.3 Targets

Macroeconomic aggregates and ratios. In Table 3 are the values of the Spanish shares for 2008. To compute those shares, we define C as the value of Spanish private consumption, I as the value of Spanish gross capital formation, and G as the value of the Spanish public consumption, all three for 2008 and measured at current market prices. These values are reported by the Spanish *Instituto Nacional de Estadística*. Our definition for Y is $Y = C+G+I$. Our values for K and h are the values for the Spanish capital stock and hours for 2008.[15] Our targets for Y_l and Y_k are the nominal GDP shares of labor income and of all income other than labor income for Spain in 2008. Our target for T_c is the indirect tax collections reported for 2008 by the Spanish National Income and Product Accounts, our target for T_k is the sum of the capital income share of the Personal Income tax collections and the Corporate Income tax collections, our target for T_l is the labor income share of the Personal Income Tax collections, and our target for T_s is the Payroll Tax collections paid by both workers and firms. All our tax statistics are reported by the OECD.[16] Finally, our definition for $T_l^* = T_l + T_s$ and our target for P is the value reported by the Spanish Social Security Administration. Since the value of C/Y is determined residually, these shares give us a total of 10 independent targets.

Table 3: Macroeconomic Aggregates and Ratios in 2008 (%)

	C/Y	I/Y	G/Y	K/Y^a	$Y_k/\tilde{Y}^b$	h	T_c/C	T_l/Y_l	T_k/Y_k	T_s/Y	P/Y
Spain	54.0	27.9	18.1	3.19	35.3	21.1	17.0	40.2	39.1	10.4	10.0

[a]The target for K/Y is in model units and not in percentage terms.
[b]Variable $\tilde{Y}$ denotes GDP at factor cost.

Preferences. We need three targets to identify the three preference parameters, α, β, and σ. To determine the values of α and β we use share of disposable time that households allocate to labor market activities h and of the K/Y ratio which we have reported in Table 3. The third target is our choice for value of σ, and we choose $\sigma = 4.0$. This gives us 1 additional target.

The life-cycle profile of earnings. To identify the three quadratic functions that we have used to model the deterministic component of the process on the endowment of efficiency labor units we need must estimate the values of 9 parameters. To do so we use the earnings profiles reported by the *Instituto Nacional de Estadística* in the *Encuesta de Salarios en la Industria y los Servicios* (2000) for the Spanish economy. This procedure allows us to estimate the 9 parameters directly and it gives us 9 additional targets.[17]

The disability risk. We want the probability of becoming disabled to approximate the disablility profile reported by the *Boletín de Estadísticas Laborales* (2007) for the Spanish economy. We use the Spanish

[15]For details on the way these series were computed, see Conesa and Kehoe (2009).
[16]Again, see Conesa and Kehoe (2009) for the details.
[17]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. The year 2000 dataset is the last data sate available on the age-profiles of wages by educational types.

data to determine the values of parameters a_9 and a_{10} in Expression (6). Further, according to the *Instituto de Mayores y Servicios Sociales*, in 2008 in Spain 62.6 percent of the total number of disabled people aged 25 to 44 years old had not completed high school, 26.9 percent had completed high school, and the remaining 10.5 percent had completed college. We use these shares to determine the values of parameters a_{11} and a_{12} of Equation (7). Specifically, we choose $a_{11} = 0.269/0.626 = 0.4297$ and $a_{12} = 0.105/0.626 = 0.1677$. This gives us 4 additional targets.

Technology. We need 3 targets to identify the technology parameters, δ, θ, and the initial value of the productivity proces B_{2008}. The values of δ and θ are implied by our targets for I/Y and $Y_k/\tilde{Y}$ which we have reported in Table 3. And we choose $B_{2008} = 1$. This gives us 1 additional target.

The pension system. To identify the payroll tax function described in Expression (17), we must choose the values of parameters a_4 and a_5. In 2008 in Spain, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first 43,037 euros of annual gross labor income. Hence, the maximum contribution was 12,179 euros which correspond to 51 percent of the Spanish per capita GDP. To replicate this number, in our model economy we choose $a_4 = 0.51$. The value for a_5, is implied by our requirement that the revenues collected by the payroll tax in the model economy match the 10.4 percent of output collected in the Spanish economy.

Our choice for the number of years used to compute the retirement pensions in our model economy is $N_b = 15$. This is because the Spanish *Régimen General de la Seguridad Social* considers the last 15 years of contributions prior to retirement to compute the pension. We assume that the minimum, and maximum pensions and the maximum covered earnings are directly proportional to per capita income. Our targets for the coefficients are $b_{0t} = 0.19$, $b_{mt} = 1.39$, and $a_6 = 1.80$. These numbers correspond to their Spanish values for 2008 for workers included in the *Régimen General*.[18]

We choose our first and normal retirement ages to be $R_0 = 60$ and $R_1 = 65$. In Spain the first retirement age was 60 until 2002. This rule was changed in 2002 when the first retirement age was delayed to 61, with some exceptions. We choose $R_0 = 60$ because in 2003 a large number of workers were still retiring at that age.[19] For the early retirement penalty parameters, we choose $a_7 = 0.4$, and $a_8 = 0.08$. This is because we have chosen $R_0 = 60$ and because in Spain the penalties for early retirement are 8 percent for every year before age 65. The value of the pension replacement rate, ϕ is implied by the requirement that our model economy replicates the pension payments to output ratio in Spain in 2008 which was 10.0 percent. Finally, for the rate of return on the pension reserve fund's assets we choose $r^* = 0.02$. The pension system gives us a total of 10 additional targets.

Other government policy targets. Our targets for the government expenditure and tax revenue ratios are those reported in the Table 3. To identify government policy, we must still target the values of E_t and Z_t and F_{2008}. Unintentional bequests, E_t, are endogenous and we do not impose any restriction on their value. We use transfers, Z_t, to satisfy the government budget and therefore their value is determined residually. Finally, our choice for the initial value of the pension reserve fund is $F_{2008} = 0.0545Y_{2008}$. This number corresponds to the value of the Spanish pension fund at the end of 2008. This gives us 2 additional targets.

Distributional targets. We target also the 3 Gini indexes and 5 points of the Lorenz curves of the Spanish distributions of earnings, income and wealth for 2004. We have taken these statistics from Budría and Díaz-Giménez (2006), and we report them in Table 8. Castañeda et al. (2003) argue in favor of this calibration procedure to replicate the inequality reported in the data. This gives us a total of 8 targets.

Normalization conditions. In our model economy there are four normalization conditions. The transition probability matrix on the stochastic component of the endowment of efficiency labor units process is a

[18]Specifically, in 2008 the minimum retirement pension in Spain was 4,616 euros, the maximum pension was 33,383 euros, the maximum covered earnings were 43,037 euros, and per capita GDP was 23,874 euros.

[19]García Pérez et al. (2008) reports that around 20 percent of age 60 active people chose to collect the retirement pension during 2007.

Table 4: Values for 28 of the Model Economy Parameters in 2008

	Parameter	Value
Preferences		
Leisure share	α	0.2275
Time discount factor	β	1.0398
Curvature	σ	4.0000
Technology		
Capital depreciation rate	δ	0.0783
Labor share	θ	0.6596
Initial total factor productivity	B_{2008}	1.0000
Government Policy		
Government consumption	G	0.5223
Government transfers	Z	0.0837
Consumption tax rate	τ_c	0.1483
Capital income tax rate	τ_k	0.3915
Labor income tax rate	τ_l	0.2295
Public Pension System		
Payroll tax cap	a_4	1.4756
Payroll tax rate	a_5	0.1188
Maximum covered earnings	a_6	5.2141
Maximum early retirement penalty	a_7	0.4000
Early retirement penalty per year	a_8	0.0800
Pension replacement rate	ϕ	0.5200
Minimum retirement pension	b_{0t}	0.5591
Maximum retirement pension	b_{mt}	4.0444
Number of years of contributions	N_b	15
First retirement age	R_0	60
Normal retirement age	R_1	65
Initial pension reserve fund	F_{2008}	0.1576
Rate of return for the pension fund	r^*	0.0200
Disability Risk		
	a_9	0.000449
	a_{10}	0.0924
	a_{11}	0.4291
	a_{12}	0.1677

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 $s(1) = 1$. These normalization conditions give us 4 additional equations.

Adding up. Notice that we have specified a total of targets which can be formalized as 49 equations. Of these 49 targets, 10 are macroeconomic aggregates and ratios, 1 describes the households' preferences, 9 the deterministic component of the process on the endowment of efficiency labor units, 4 the disability risk, 1 describes technology, 10 describe the pension system, 2 the remaining components of government policy, 8 are target distributional statistics, and 4 are normalization conditions. The 49 parameters and the 49 targets define a full rank non-linear system of 49 equations in 49 unknowns.

Table 5: The Deterministic Component of the Endowment Process

	$h = 1$	$h = 2$	$h = 3$
$a_{1,h}$	–1.3018	–2.9624	–6.2441
$a_{2,h}$	0.1305	0.2334	0.4227
$a_{3,h}$	0.001091	0.001997	0.003582

4.4 Choices

We obtain values of 30 of the model parameters directly either because they are determined uniquely by single targets, or because they are normalization conditions. These parameters are independent of the endogenous variables of the model. The values of 5 of the remaining parameters are implied by our guesses for aggregate capital and labor. To determine the values of the remaining 14 parameters, we solve the system of 14 non-linear equations in 14 unknowns obtained from imposing that the relevant statistics of the model economy should be equal to the corresponding targets. Solutions for these systems are not guaranteed to exist and, when they do exist, they are not guaranteed to be unique.[20] Consequently, we tried many different initial values in order to find the best parameterization possible. To solve this system of equations we use a standard non-linear equation solver. Specifically, we use a modification of Powell's hybrid method, implemented in subroutine DNSQ from the SLATEC package. We report the numerical choices for the 49 model economy parameters in Tables 4 and 5, and in the first two blocks of Table 6.

Table 6: 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	0.8786	0.1213	0.0000	43.12
$s = s_2$	3.5047	0.1236	0.8757	0.0004	42.31
$s = s_3$	4.2253	0.0000	0.0017	0.9982	14.55

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

4.5 Calibration Results

Macroeconomic Aggregates and Ratios. In Table 7 we report the macroeconomic aggregates and ratios in Spain and in our menchmark model economy for 2008. We find that our benchmarks model economy does a good job in replicating the values of the chosen targets.

[20] Actually we solved a smaller system of 13 equations and 13 unknowns because the value of Z is determined residually from the government budget.

Table 7: Macroeconomic Aggregates and Ratios in 2008 (%)

	C/Y	I/Y	G/Y	K/Y^a	$Y_k/\tilde{Y}^b$	h	T_c/C	T_l/Y_l	T_k/Y_k	T_s/Y	P/Y
Spain	54.0	27.9	18.1	3.19	35.3	21.1	17.0	40.2	39.1	10.4	10.0
Model	51.2	30.7	18.1	3.19	35.3	21.1	14.8	40.0	39.1	10.6	10.0

[a]The target for K/Y is in model units and not in percentage terms.
[b]Variable $\tilde{Y}$ denotes GDP at factor cost.

Distributional Statistics. 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 model economy. The statistics that we report in bold face are our eight calibration targets. The source for the Spanish data is the 2004 *Encuesta Financiera de las Familias Españolas* as reported in Budría and Díaz-Giménez (2006b). The model economy statistics correspond to 2008. We find that our heterogeneous household model economy replicates reasonably well the Spanish Gini indexes of the earnings and income distributions. When we compare the earnings and income shares of the quintiles we find that the bottom forty percent of both distributions earn lower shares in the model economy than in Spain, and that the top two quintiles of both distributions earn more. The fact that the model economy can account for the Lorenz curve of income reasonably well is particularly remarkable since we have not used any of its points as our calibration targets. We also find that wealth is more concentrated in our model economy than in Spain. This is due to a larger concentration of wealth in the top two quintiles. In spite of this, the largest differences between our heterogeneous household model economy and the Spanish data are in the the top 1 percent of the wealth distribution where wealth is sizably more concentrated in Spain. This disparity was expected because in general, overlapping generations economies fail to account for the large shares of wealth owned by the richest households in the data.[21]

Table 8: The Distributions of Earnings, Income and Wealth*

		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	**0.49**^{a}	0.0	0.7	1.2	**5.3**	**10.9**	**16.2**	**23.3**	**44.3**	10.9	11.5	5.6
Model	0.49	0.0	0.0	0.1	0.7	4.7	19.9	27.8	46.9	11.1	13.0	4.0
The Income Distributions (%)												
Spain	**0.42**	0.0	0.7	1.1	5.4	10.7	15.9	23.3	44.6	10.7	11.1	6.4
Model	0.42	0.1	0.6	0.9	4.0	8.3	16.5	26.8	44.4	10.6	12.5	4.1
The Wealth Distributions (%)												
Spain	**0.57**	–0.1	–0.0	0.0	0.9	6.6	12.5	20.6	59.5	12.5	16.4	13.6
Model	0.53	0.0	0.0	0.0	0.4	6.2	14.9	26.2	52.3	12.6	14.9	5.8

*The source for the Spanish data is the 2004 *Encuesta Financiera de las Familias Españolas* as reported in Budría and Díaz-Giménez (2006b). The model economy statistics correspond to 2008.
[a]The statistics in bold face have been targeted in our calibration procedure.

Retirement Behavior. In the first panel of Table 9 we report the average retirement age in Spain and in our heterogeneous household model economy. We find that the average retirement age in our model economy is 63.1 years, which is 0.5 years more than in the Spanish economy.[22] We also find that the average retirement ages in the model economy are increasing in the number of years of education. This finding was to be expected since the returns to working are increasing in the number of years of education. We do not have the corresponding data for the Spanish economy but we think that this increasing relationship is intuitively plausible.

[21]See Castañeda et al. (2003) for an elaboration on this argument.
[22]The Spanish average retirement age has been computed for both male and female workers, it corresponds to the year 2008 and it is reported in Eurostat. Every number reported in this section for our model economy corresponds to the year 2008.

Table 9: Retirement Behavior

	Avg Ret Ages		% Min Pension		% Part at 60-64		
	Spain[a]	Model	Spain[b]	Model	Spain[c]	Model	Spain[d]
All	62.6	63.1	27.1	20.8	36.4	46.2	56.6
Dropouts	*n.a.*	62.5	*n.a.*	24.9	30.5	37.5	49.5
High School	*n.a.*	63.9	*n.a.*	9.3	40.1	60.7	64.9
College	*n.a.*	64.9	*n.a.*	7.6	57.1	71.5	66.7

[a]The Spanish data is for both males and females in 2008 (Source: Eurostat).
[b]The Spanish data is at the end of 2008 (Source: Seguridad Social).
[c]The Spanish data is the average of the four quarters of 2008 of the *Encuesta de la Población Activa*.
[d]The Spanish data is the average of the four quarters of 2008 of the *Encuesta de la Población Activa*, excluding the unemployed and non-participants who do not collect either retirement or disability pensions.

In the central panel of Table 9 we report the share of all retirees collecting the minimum retirement pension. We find that this share in our model economy is 20.8 percent, which is 6.3 points lower than in the Spanish economy. We also find that this share is decreasing in the numbers of years of education. Unfortunately, we do not have the corresponding data for the Spanish economy, but we think that this relationship is plausible.

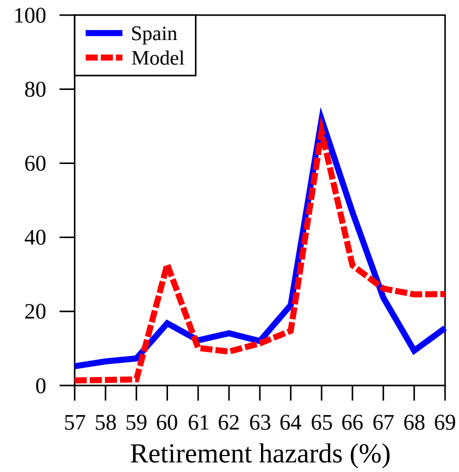
In the last panel of Table 9 we report the labor participation rates of the households that belong to the 60–64 age cohort. When carrying out this comparison we must keep in mind that there are some fundamental differences between Spain and our model economy. In Spain, working-age people fall into one of five categories: employed, unemployed, retired, disabled, and other non-participants. In our model economy we only have three of these categories: employed, retired, and disabled. These differences account for the large differences between the data in the third and the fifth columns of that table. In the third column we include the participation rates as reported by the *Encuesta de la Población Activa.* In the fifth column we report the participation rate excluding from the non-participants both the unemployed and the non-participants who do not collect retirement or disability pensions. We find that the participation rates in our model economy lie between these two estimates of the Spanish participation rates, and that they come very close to the numbers that we have obtained using our second measure. This finding is particularly encouraging because the participation statistics are not part of our calibration targets. Therefore they can be interpreted as overidentifying restrictions for our model economy.

Again we find that the participation rates of the elderly are increasing in education both in our model economy and in the data. Two reasons justify this relationship. First, many dropouts are entitled to minimum pensions only. Consequently, these workers are not affected by the early retirement penalties and 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 less educated workers. Consequently, more educated workers tend to participate more than their less educated colleagues.

In Figure 2 we report the probabilities of exiting the labor force due to retirement or disability. Naturally these exit probabilities are conditional on being a worker at the beginning of the period.[23] Two features stand out from this comparison. Qualitatively, our model economy does a fair job in replicating the general shape of the retirement and disability hazards observed in Spain. Quantitatively, more households retire in our model economy at age 60 (32 percent of the sixty year olds in the model economy and 17 percent in Spain) and less at 65 (68 percent of the sixty year olds in the model and 72 percent in Spain). Part of this discrepancy can be due to the fact that to calibrate our model economy we target hours worked per person in the 16–65 age cohort, which are approximately 21 percent. To replicate this low number, households in our model economy must value leisure a lot. If we had targeted the number of hours worked per labor market participant, which was approximately 28 percent according to the *Instituto Nacional de Estadística*, the model economy households would have valued leisure less and therefore more of them would have chosen to extend their working-lives beyond the first retirement age. In contrast between ages 61 and 64 the probabilities of retiring are higher in Spain than in the model

[23]The Spanish data are reported in Jiménez-Martín (2006) and they correspond to Spanish males in 2003.

Figure 2: Probabilities of exiting the labor force



economy.

5 Simulation

To simulate our model economy and to project it into the future we do the following:

(a) We choose a demographic scenario that determines the population dynamics and the educational transition.

(b) We choose an economic scenario that determines the growth of productivity.

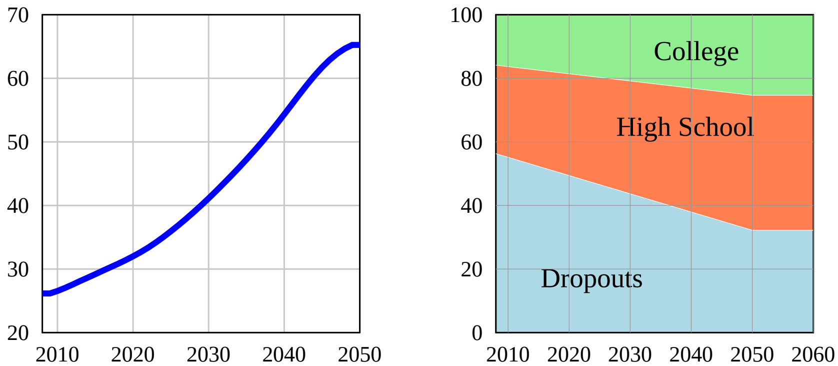
Our benchmark economy and our reformed economies share both the demographic and the economic scenario. The simulation of the benchmark model economy allows us to evaluate the sustainability of the current pension system in the chosen scenario. The reformed economies change some feature of the pension system and their simulation allows us to evaluate the aggregate, distributional and welfare consequences of the reforms.

The Demographic Scenario. The age and the educational transitions are completely independent from the economic decisions, and they are determined by the survival probabilities, the fertility rates, and the flows of immigrants all of which are exogenous. We have discussed these transitions in detail in Díaz-Giménez and Díaz-Saavedra (2006), and for the sake of brevity we do not discuss them here.

The time series that describe the evolution of the population and its composition by age and educational levels, are constructed from Meseguer (2001) and the information published by INE. In Panel A of Figure 3, we show the evolution of the dependency ratio in our model economy, and in Spain according to the INE's last population projection. In Panel B of that same figure, we show the educational transition. This transition shows that the shares of workers with high school and college studies increases, and that the share of dropouts workers decreases.

The Economic Scenario. We assume that the value of the growth rate of the labor-augmenting productivity process is $\gamma = 0$.

Figure 3: The Demographic and Educational Transitions



6 Results: The Current System is Unsustainable

In this section we report the results concerning the future sustainability of the current Spanish public pension system.

In Díaz-Giménez and Díaz-Saavedra (2009), the demographic transition replicated the Hypothesis 1, a former population projection maked by INE. According to that projection, the old-age dependency ratio of the Spanish economy, which we defined as the ratio of the number of people in the 65+ age cohort to the number of people in the $20-64$ age cohort, would increase from 26.5 percent in 1997 to a projected 59.9 percent in 2050. Under this demographic scenario, we found that the pension system started running a deficit in 2016, the pension fund depletion was in 2028, and that the pension deficit was 6.8 percent of GDP in 2050.

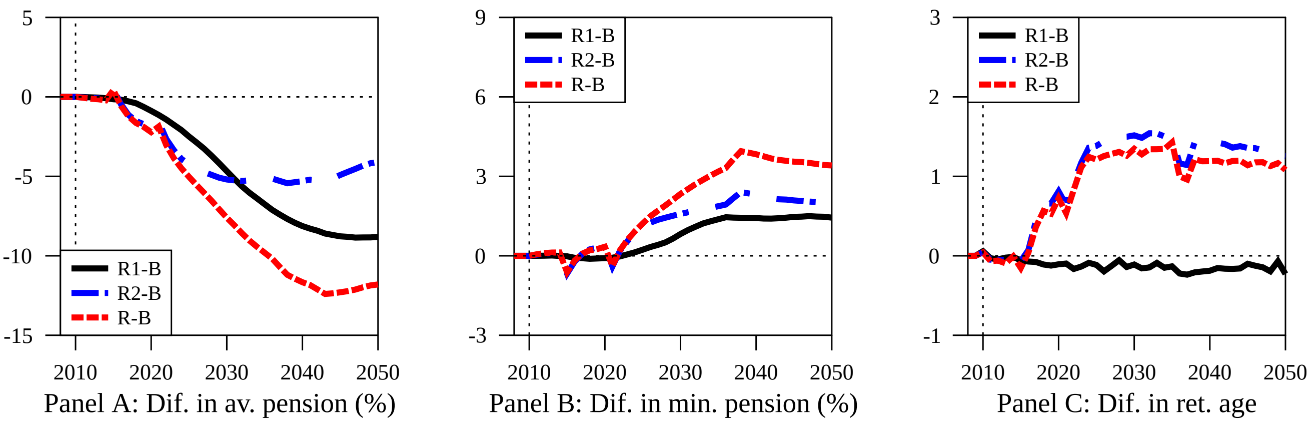
In this paper, our demographic transition replicates the last INE's projection about the evolution of the population in Spain. According to the INE, the old-age dependency ratio will now increase from the current 26.1 percent to 65.2 percent in 2049, 5 percentage points more than in the previous projection. Then, and as expected, a more pesimistic demographic scenario show that sustainability of the current Spanish public pension system is reduced. Specifically, in this paper we find that the first pension deficit appears in 2015, the fund depletion is in 2025, and that the pension deficit is 10.2 percent of GDP in 2050.

7 Results: The Reforms

This section reports our findings on the consequences of reforming the Spanish pension system in accordance with the Government's proposal. This proposal, announced at the beginning of 2010, contains two main parametric changes. Firstly, a gradual increase in the number of years used to compute the retirement pension, starting in 2013. Presently, the regulatory base, which is the main component of the retirement pension, is computed as average labor earnings during the last 15 years before retirement. The reform increases this averaging period, so that the regulatory base becomes an individual's average labor income during the last 25 years. The Government's proposed time scale is to increase the regulatory base by one year each year from 2013 onwards, and this time scale is used in our analysis.

The second change increases the statutory retirement ages by two years, from the current 60 and 65 to 62 and 67 years of age. The proposed time scale increases this age by two months per year, starting in 2013. Consequently, in comparison to the present, this statutory retirement age will be one year higher

Figure 4: Differences in pensions, minimum pensions, and retirement ages



in 2018 and two years higher in 2024. However, in our model economy, and because a period corresponds to one year, we cannot replicate the time scale the Government proposes. We therefore decided to raise the legal retirement ages by one year in 2015. Thus, the first six months of the increase which our time scale is unable to capture is compensated for by an advance increase of the remaining six months. We apply the same time scale to the second increase in the legal retirement ages, which are therefore raised once more by one year in 2021.

Finally, we make two additional assumptions. First, we assume that these parametric changes affect every household who had not retired by the end of 2012. And second, we also assume that the sequences of government expenditures, transfers, capital and labor tax rates are identical in the benchmark and the reformed model economies, which differ only in payroll tax collections, pension payments and unintentional bequests (which are endogenous) and in consumption tax rates, which we adjust to satisfy the government's budget.

7.1 Individual consequences

The two parametric changes made by this reform have different consequences for pensions and retirement behavior. To fully understand these consequences, we perform three different exercises. In the first exercise, R_1, we increase by ten the number of years of labor income used to compute the retirement pension, from the last 15 to the last 25 years. In the second exercise, R_2, we increase the first and the normal retirement ages by one year in 2015, and by a further one year in 2021. Finally, in the last exercise, R, we simultaneously implement both previous parametric changes. That is, we implement the government's proposed reform.

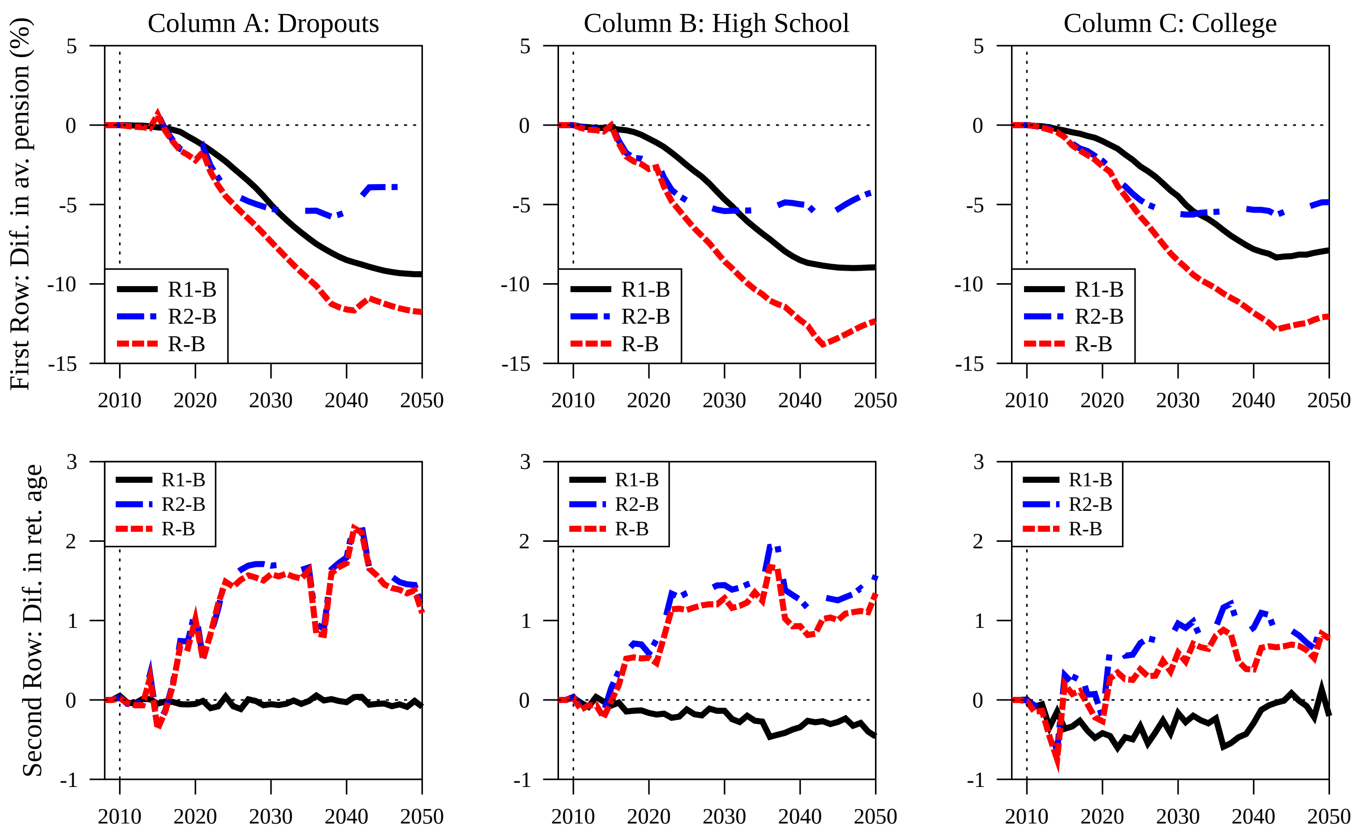
Retirement pensions

Increasing the number of years of labor income used for pension calculation reduces the new retirement pensions by 9 percent. Consequently, the average retirement pension is 8.8 percent lower in 2050 (see Figure 4). This is because labor earnings decrease for younger workers, as they are less productive. This decrease in retirement pensions means that more workers collect the minimum retirement pension when they decide to retire, as Figure 4 shows. This most affects workers with lower educational levels, since they have a lower labor earnings profile during their working lifetime.

Increasing the statutory retirement age by two years also reduces the new retirement pensions by 4.1 percent, so the average pension is also 4.1 percent lower in 2050 (see Figure 4). This is because labor earnings decrease at the end of working lifetime and also because the effective retirement age increases by 1.3 years (see below) instead of two years, meaning that more households opt for early retirement and, consequently, face penalizations regarding their pensions. As in the previous exercise, we find that the number of households collecting the minimum retirement pension increases.

Finally, in our last exercise we find that the average pension decreases by 11.8 percent by 2050. By educational groups, this reduction is 11.7, 12.4, and 12.1 percent respectively. This reform reduces pensions to a greater extent because both previous changes are implemented simultaneously, and there is also a greater increase in the number of households collecting the minimum pension.

Figure 5: Differences in pensions, minimum pensions, and retirement ages



The average retirement age

Increasing the number of years of labor income used to compute pensions does not significantly affect the retirement behavior of older workers. Lower pensions imply a lower opportunity cost of continuing to work, so workers tend to delay retirement. But lower pensions also mean that some workers, specially those with a lower educational attainment, will collect the minimum retirement pension when they decide to retire. And because the minimum pension is exempt of early retirement penalizations, these workers choose to collect this minimum amount as soon as it is available i.e. at the first retirement age. Consequently, the two effects cancel each other out (see Figure 4).

Increasing the statutory retirement age by two years increases the average retirement age by 1.3 years, and not two years, because the following. By working one more year, workers reduce the penalization for early retirement, so their pensions increase by 8 percent. However, labor earnings decrease at the end of working lifetime, and therefore working for one additional year could result in a lower average labor

Table 10: The pension system and the VAT rate

	2010	2020	2030	2040	2050
	The Payroll Tax (% GDP)				
Benchmark	10.50	10.46	9.97	9.51	9.07
Reform	10.71	10.51	10.30	9.86	9.46
	The Pension Payments (% GDP)				
Benchmark	10.06	11.21	13.26	16.28	19.31
Reform	10.07	10.78	11.49	13.78	16.54
	The Pension Deficits (% GDP)				
Benchmark	–0.44	0.75	3.29	6.77	10.23
Reform	–0.64	0.26	1.19	3.92	7.08
	The Pension Funds (% GDP)				
Benchmark	6.52	5.53	0.00	0.00	0.00
Reform	6.71	9.22	6.88	0.00	0.00
	The VAT rate (%)				
Benchmark	14.87	15.00	22.44	30.01	38.24
Reform	14.22	14.98	12.98	22.05	29.10

income prior to retirement. Thus, for some workers, especially the least productive, it is still optimal to leave the labor market before the normal retirement age.

In our last exercise, we find that the average retirement age increases in 1.1 years, and by educational groups, this increase is 1.1, 1.3, and 0.8 years (see Figure 5). Note that these increases are lower the higher the educational attainment of workers, since the more educated workers tend to leave the labor market at older ages, in comparisson to their colleagues.

7.2 Aggregate consequences

In this subsection, we report the findings concerning the aggregate consequences of implementing both parametric changes together. This is precisely the government's proposal to reform the Spanish public pension system. Thus, we only report the results concerning our last exercise, R.

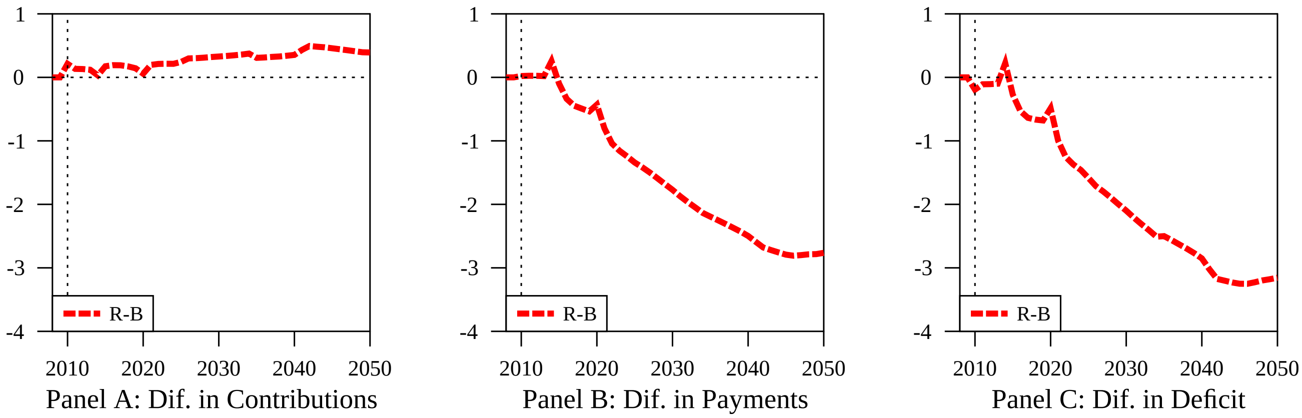
The pension system and the VAT rate

In the previous subsection we found that an increase in both the number of years used for pension calculation and in the statutory retirement ages reduces retirement pensions and increases the average retirement age. It should be noted that this second effect is equivalent to a decrease in the effective dependency ratio. Consequently, both effects reduce pension payments.

According to the Spanish Government, this reform should reduce pension payments in 4 percentage points of GDP. However, we find that these payments fall less than 3 points of GDP. For example, such payments fall from 19.3 to 16.5 percent of GDP in 2050 (see Figure 6). This discrepancy could be because two reasons. Firstly, because the pension reduction that follows the increase in the number of years used to pension calculation is lower in our study, since our model economy can account for the fact that the retirement pension can not fall below the minimum retirement pension. And secondly, despite the reform increases in two years both statutory retirement ages, the effective average retirement age increases in 1.1 years.

With regard to contributions, the reform increases them in 0.4 points of GDP in 2050 (see Figure 6). Thus, this reform reduces the long-run deficit of the pension system from 10.2 percent of GDP to 7.1 percent in 2050, and also postpones the first pension deficit by 9 years, from 2015 under current arrangements

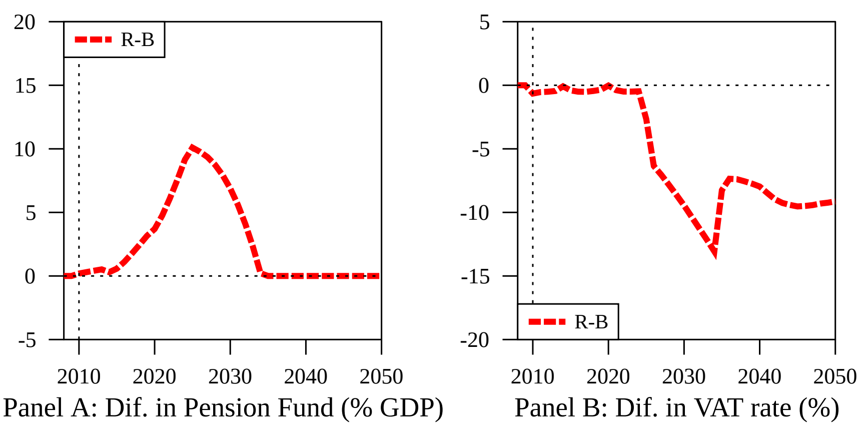
Figure 6: Differences in contributions, payments, and deficit (% GDP)



to 2024 under the reform. Consequently, this reform also postpones pension fund depletion by 10 years, from 2025 to 2035 (see Figure 7)

The implications of this reform for the VAT rate are straightforward. Firstly, and due to the postponement of fund depletion, the VAT rate is also increased 10 years later under the reform. Secondly, the VAT rate needed to finance the long-run pension deficit is reduced by 9 points in 2050, from 38.2 to 29.1 percent (see Figure 7)

Figure 7: Differences in the pension fund and the VAT rate

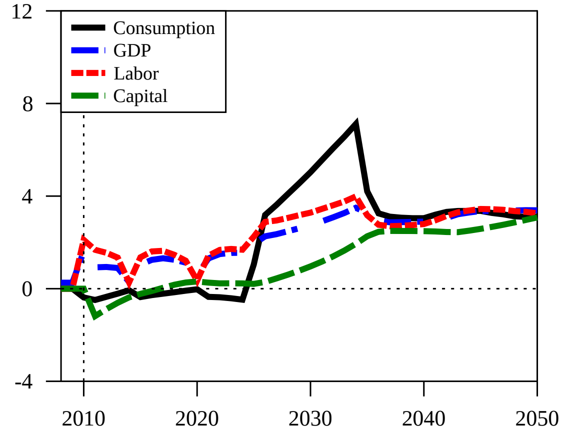


The factor inputs, the GDP, and the aggregate consumption

We find that the reform increases both factor inputs. Capital increases due to lower retirement pensions; for example, it is 3.1 percent higher in 2050 under the reform. In turn, effective labor is 3.3 percent higher in 2050 under the reform, since the average retirement age is higher. Consequently, we find that the reform is expansionary, as it increases GDP by approximately 3.1 percent that same year. (see Figure 8)

With regard to aggregate consumption, it is higher by around 3.1 percent because the lower VAT rate compensates the lower retirement pensions.

Figure 8: Differences in factor inputs, GDP, and aggregate consumption



7.3 Welfare consequences

So far, we have seen that the reform reduces leisure and pensions. However, it also reduces the long-run imbalance in the pension system and, consequently, the VAT rate needed to finance future pension deficits. Specifically, we find that under current pension rules, pension fund depletion occurs in 2025, and thus the VAT rate is increased thereafter. Under the reform, however, this fund depletion takes place in 2035, and the VAT increase required from then onwards is lower, as the pension budget imbalance is also lower.

Subsequently, to evaluate the effects of this trade-off upon household welfare, we compute a Consumption Equivalent Measure (CEM). Specifically, we quantify the welfare change of this reform for households by calculating by how much household consumption would have to increase each period in the benchmark economy for its expected future utility to equal that under the reform. Then, a positive CEM means that a household of type (h, j) will experience an increase in his/her welfare after the reform.

Households alive at the moment of the policy change announce

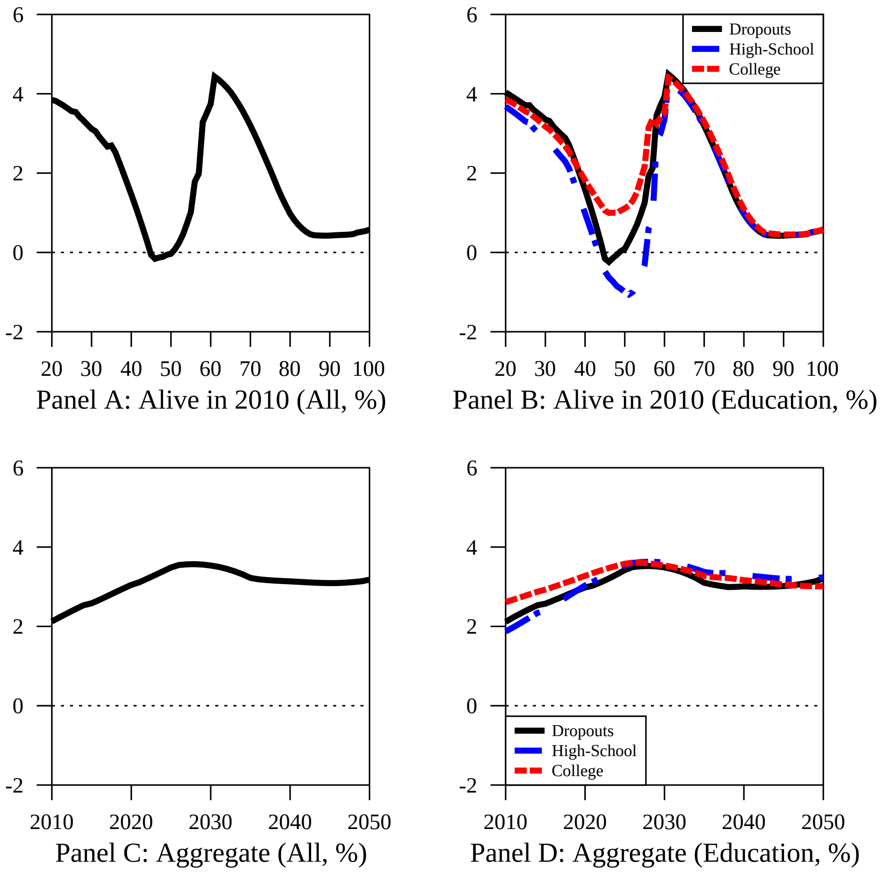
The impact of this reform on household welfare depends principally on their labor status, age, and education. We find that most of the households alive in 2010 are better off under the reform, for the following reasons:

Retirees: already retired households are not affected by the decrease in retirement pensions, as their pension entitlements are not affected by the reform. Consequently, they are only affected by the change in factor prices, and the VAT rate. There is not significant variation in factor prices after the reform, as both factor inputs increase altogether in similar proportions. However, the reform reduces the VAT rate, specially after 2025. Consequently, all retired households are better off following the reform (see Panel A of Figure 9). It should be noted that as age increases, these welfare gains decrease, since such households have fewer years in which to benefit from the lower consumption tax. From the age of 86 upwards, these welfare gains are constant, and they only reflect the slighty lower VAT rate following the reform, since all such households will be dead by 2025.

Workers: we find that most workers are better off under the reform, which affects all households aged 61 or under since it is to be implemented from 2013 onwards, despite being announced in 2010. Thus, workers aged 61 years or more will enjoy the same leisure and will receive the same pension under the reform. Consequently, the higher welfare gains at older ages, mainly related to lower future taxation, correspond precisely to this age (see Panel A of Figure 9)[24].

[24] In fact, workers aged 61 or over may also be affected by the reform, if they choose to retire after 2013 i.e. when aged 64 or

Figure 9: The Consumption Equivalent Measure



For those workers aged 60 or under, welfare gains decrease, and in some cases become losses. This is because such workers would be affected at least partially by the increase in both the legal retirement ages and the number of years used for pension calculation. These welfare losses are most severe for workers currently aged 46, as they are the current older workers that receive the full impact of these two parametric changes. Finally, workers under 45 enjoy welfare gains, since reduced leisure and pensions are compensated for by longer periods of lower taxation.

With regard to education, we find that all college workers enjoy welfare gains (see Panel B of Figure 9). Despite their pensions being reduced by over 12 percent, this represents only a fraction of their retirement income, since they are the richest households in the economy. In addition, the postponement of the statutory retirement ages does not significantly affect such households, as they already choose to leave the labor market later than other workers.

Surprisingly, and contrary to popular wisdom, it is not the least qualified workers who are most negatively affected, but instead those with an intermediate educational level. Firstly, their retirement pension will decrease by over 12 percent once they decide to retire, in comparisson to the 11 percent decrease for dropouts. And secondly, they increase their effective retirement age by more than low-educated households.

In conclusion, the workers most negatively affected by this reform are within the 45-55 age range, since they are the oldest workers to whom the total or almost the total increase in the number of years used

over. Since most workers choose to retire between 60 and 64 years old uder the current pension system rules, the number of workers within this age group affected by the reform is very low.

for pension calculation and in the legal retirement ages will be applied. This is because, in addition to having less time to reoptimize their optimum decisions, these workers enjoy fewer years with lower VAT, in comparison to younger workers.

Future cohorts

Unsurprisingly, when we compute welfare across all those households alive in 2010, we find that the aggregate measure is positive (see Panels C and D of Figure 9). Furthermore, if we compute this aggregate measure from 2010 onwards, it is positive and increases until 2025, from when on it stabilizes at approximately 3 percent. In conclusion, all future cohorts are better off under the proposed reform of the pension system, because lower lifetime taxation compensates for lower leisure and pensions.

8 Conclusions

We use an overlapping generations model economy, calibrated to Spanish data for 2008, to analyze the Government's proposal to reform the Spanish pension system. This proposal was formally presented to the European Commission at the beginning of 2010, and advocates both increasing the statutory retirement ages by two years and increasing the number of years of labor income used for pension calculation by 10 years, from the last 15 to the last 25 years before retirement.

We find that the reform reduces pension payments, and consequently postpones the first pension deficit by 9 years and the depletion of the pension fund by 10 years. Thus, it improves the long-run sustainability of the Spanish pension system, although it cannot restore its long-run balance. We also find that this reform is expansionary. Finally, we find that despite the reductions in leisure and pensions it entails, lower future taxation improves the welfare of most households currently alive, especially those with a higher educational level.

We end by making two policy recommendations. Firstly, and despite the reform being a good initial attempt to cope with the problems of long-run sustainability plaguing the Spanish pension system, we consider that deeper reforms should be implemented, such as increasing the averaging period of the regulatory base to the entire working lifetime, and increasing the statutory retirement age by more than the two years proposed. Apart from the positive effects which these recommendations may have upon the budget of the pension system, we consider that they offer additional advantages. Implementing the first recommendation would give the public pension system greater intragenerational equity. With regard to the second, it seems sensible to extend working lifetimes by more than 2 years, bearing in mind that life expectancy at birth has increased by 4 years in the last 20 years in Spain, and is predicted to increase by a further 6 years in the coming 40.

Secondly, any reform of the public pension system is widely unpopular. In fact, the reaction of Spanish society to this proposal has been, in general, one of rejection, for two reasons. First, citizens have not been informed, through a clear and precise diagnosis, of the grave future financial situation faced by the public pension system due to population ageing. And second, and relatedly, only the potential disadvantages (longer working life and lower retirement pensions) of this reform have been indicated, while nothing has been said concerning the benefits derived from the lower future tax rates necessary to balance the pension budget. Consequently, we believe that in addition to informing citizens of the future financial inviability of the current pension system, the benefits such reforms bring must be explained. Specifically, that the costs borne by current workers can be widely compensated for by the lower future tax rates required to balance the pension budget.

References

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

[2] 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.

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

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

[5] 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.

[6] Conesa J. C., and T. J. Kehoe, (2009). Productivity, taxes, and hours workerd in Spain: 1970-2000. Mimeo.

[7] Da Rocha J., and Lores F., (2005). '?Es urgente reformar la seguridad social?. RGEA working paper 05-05.

[8] 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.

[9] Díaz-Giménez J., and J. Díaz-Saavedra, (2009). Delaying retirement in Spain. *Review of Economic Dynamics 12*, 147–167.

[10] Gustman A, and Steinmeier T, (1986). A structural retirement model. *Econometrica 54*, 555-584.

[11] 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.*

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

[13] Jimeno J., (2003). La equidad intrageneracional de los sistemas de pensiones. *Revista de Economía Aplicada 33* , XI, pp. 5-48.

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

[15] Sánchez-Martín A., (2010). Endogenous retirement and public pension system reform in Spain. *Economic Modelling 27,* 336–349.