Centro Atlántico de Estudios Ríos Pérez

Endogenous Retirement and Public Pension System Reform in Spain

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CAERP

Documento de Trabajo # 17

Working Paper # 17

Endogenous Retirement and Public Pension System Reform in Spain * †

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First Draft: April 2001
This version: July 2003

Abstract

All around the world, developed countries have resorted to *parametric* reforms of their Social Security systems, in an attempt to lessen the impact of the population aging. In this paper we explore the capacity of these reforms to alleviate the expected financial difficulties of current PAYG systems. This is accomplished by developing a Heterogeneous Agents, Applied General Equilibrium model where individuals can freely adjust their retirement ages in response to the incentives provided by the pension regulations. We find that the calibrated model successfully reproduces the basic stylized facts of retirement behavior in Spain. In particular, it mimics the early retirement pattern of low income workers under the effects of minimum pensions. The model is then used to explore the effects of several changes in pension formula, including the reform actually implemented in 1997. The general conclusion is that *parametric* changes can significantly improve the financial condition of the system, but are not enough to fully restore it. *Journal of Economic Literature* classification Numbers: D58, H55, J14, J26

Key Words: Applied General Equilibrium, Retirement, Pension System Reform

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*This research is an extension of one my dissertation chapters, funded from a Marie Curie Fellowship of the European Community programme "Improving Human Research Potential and the Socio-economic Knowledge Base" under contract number HPMF-CT-2002-01626. The views expressed herein are those of the author, and not necessarily those of the Community. I am grateful to Michele Boldrin, Javier Díaz Giménez, María J Luengo, Sergi Jiménez and Juan Rojas for useful comments and suggestions. I also thank seminar participants at MadMac, Universidad Carlos III, Universidad de Murcia, Universitat de les Illes Balears, FEDEA, XXVI Simposio de Análisis Económico (Alicante) and 2002 Conference on microeconometric models and simulation tools for fiscal policy (Instituto de Estudios Fiscales). Of course, all remaining errors are mine.

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1 Introduction

The aging of the population has cast considerable doubts about the future financial viability of Pay As You Go (PAYG) Social Security systems. The ensuing academic and public debate has resulted in a wide variety of proposals, ranging from minor reforms of the current systems to their substitution with private and/or funded mechanisms. However, most industrialized countries have not gone any further than introducing mild *parametric* changes to the existing public systems.[1] The majority of those reforms have aimed to reduce current systems' generosity, to increase the linkage between contributions and pension benefits and to encourage older workers' labor participation.

The project In this paper we explore the ability of this type of reforms to enhance the financial prospects of PAYG public pensions systems within a fifty years horizon. This is undertaken via simulation in an Heterogeneous Agents, Large Scale, Overlapping Generations (OLG) model calibrated to reproduce the Spanish demographic process, the institutional details of the Spanish Old Aged pension system, the average retirement age and the basic macroeconomic aggregates of the Spanish economy.

Previous answers Auerbach and Kotlikoff (1987) methodology has been very fruitful in the study of the non-stationary, short run effects of aging on savings and the Social Security financial balance. Previous examples are Chauveau and Loufir (1997), Kenc and Perraudin (1997b), Miles (1999), Kotlikoff, Smetters, and Walliser (2000) and (for the Spanish case) Conesa and Garriga (1999) and Rojas (2000).[2] More specifically, the capacity of parametric reforms to help to cope with the burden of demographic changes has been the subject of two previous papers. The first one is Auerbach, Kotlikoff, Hagemann, and G. Nicoletti (1989), where the impact of a 20% reduction in the pension replacement rate and of a two years increase in the mandatory retirement age are explored. These analyses are implemented in a deterministic, large scale OLG model calibrated to generate quantitative predictions for several developed economies. It is found that both changes produce significant macroeconomic effects and substantial reductions in the size of the fiscal adjustment needed to keep the Social Security budget balanced. They generate significant welfare gains for the future generations, but at the expense of damaging the cohorts of active workers at the time the reforms are implemented. These findings are very similar to those reported in De Nardi, İmrohoroğlu, and Sargent (1999), in a model including labor income uncertainty and time varying survival probabilities and demographic patterns. This enhanced model is used to explore the consequences of linking pension benefits to the record of individual contributions, of making the pension benefits subject to taxation and of progressively delaying the *mandatory*

[1] See Kalisch and Aman (1998) for a detailed survey of the reforms implemented in OECD countries.

[2] Another reference for the Spanish case is Rios-Rull (2001), although this paper implements a different type of equilibrium (recursive) and completely abstracts from Social Security.

retirement age.

There are some aspects of this previous literature that are not entirely satisfactory. In first place, real world governments cannot directly determine the workers' retirement age. In general, they can only affect individual behavior indirectly, by changing the *incentives* implicit in the pension rules. Consequently, whether parametric reforms can actually alter individual retirement decisions remains an opened question. Secondly, reductions in the pensions' generosity can increase the marginal cost of working at advanced ages, and therefore increase the incentives to retire early. As *early* retirees are typically more expensive to the pension system than the *normal* ones, this side effect can lessen the positive impact of generosity reductions on the Social Security accounts. This aspect has not been addressed in the previous literature, which (by assuming a mandatory retirement age) has abstracted completely from the existence of Early Retirement.[3]

This paper For the first time in this literature, retirement is treated as an endogenous variable. This allows us to study the effectiveness of *real world* policies aimed to delay retirement. It also makes possible to account for the indirect impact (through behavioral changes) of parametric reforms on the pension system's balance. We explore two types of legislative changes:

(i) Reductions in the system's generosity, through changes in the length of the pension formula's averaging period.

(ii) Delays in the *Normal* retirement age.

In Spain, the length of the averaging period was increased from 8 to 15 as part of a set of small legislative changes introduced in 1997. We explore this previous reform and a further extension of this number to 30, according to a recent and highly controversial governmental proposal. Changes in the *legal* retirement age have already been implemented in the US and are likely to be considered in the near future in Spain and in other European economies facing similar demographic difficulties.

In order to properly handle the effects of these changes we design a model economy where individuals decide when to retire, private markets are incomplete (borrowing from future pension income is forbidden and there is no annuity market), there are intra-cohort differences in labor earnings and hours worked, pensions are computed according with the rules in the main pension scheme in Spain, and flows of workers from abroad are allowed. Relative to the previous literature, our main contributions are the endogenous treatment of retirement and the implementation of the borrowing constraint at the end of the life cycle, following the procedures in Crawford and Lilien (1981), Fabel (1994) and Leung (2000).

Findings We first show that our calibrated general equilibrium model is capable of reproducing the basic stylized facts of retirement in Spain. Minimum pensions

[3] Such an abstraction could be legitimate if the pension benefits were adjusted with retirement age in an actuarially fair way, but that is not the case in the Spanish pension system.

and the inclusion of labor income heterogeneity are the critical ingredients for this achievement. We then explore the impact of the parametric reforms described above, with the following results:

- If kept in its current form, the public pensions system would run into deficit from 2025 onwards. The imbalance will peak around 2050, at a figure close to a 9% of GNP. General equilibrium effects have a minor contribution to *worsen* the financial balance of the system during the second half of the simulation interval.

- The 1997 reform has no significant impact on the generosity of the system and, therefore, completely fails to alleviate its financial condition.

- The proposed additional reforms, in contrast, successfully achieve their immediate targets. Increasing the *legal* retirement age make most workers willing to keep in the labor force until more advanced ages, while extending the averaging period till 30 years makes the system significantly less generous. Consequently, the size of the social security deficit is substantially reduced in both cases; although it is still far from disappear.

- The inter-generational welfare effects of the reforms are quite similar to those already found in the previous literature. We contribute some new results about the key role played by the minimum pensions on the intra-generational welfare effects of the reforms.

Sectioning The rest of the paper is organized as follows. In section 2 we review the basic empirical labor supply patterns of advanced-aged workers in Spain, and discuss their interactions with the public pension rules. This analysis provide the motivation for the basic ingredients of our model economy. In section 3 we describe our benchmark model, while section 4 discusses its calibration to the Spanish economy. The results of the simulations are reported in section 5, although several tables and graphs are confined to a final appendix. Some details of the solution technique employed and the calibration of the model are also confined to appendix A to B. The paper finishes with some concluding comments in section 6.

2 Pension rules and the labor supply of older workers

In this section we review the basic labor supply patterns of older workers in Spain, and discuss their economic interpretation. We focus on the interaction between pension rules and retirement behaviour. This analysis provides the rationale for our modelling choices in section 3. We start with a brief review of Old Age pension rules in Spain.

2.1 Old Age pension regulations in Spain

In this section we briefly describe the Old Age pension regulations in the General Regime (RGSS), the most important pension program in the Spanish Social Security System.[4]

Financing: The system runs on a PAYG basis, ie it is financed from current active workers contributions. When the contributions raised are not enough to cover the expenses of the system, the usual practice is to resort to general fiscal revenues. Contributions are a fixed proportion of gross labor income between an upper and a lower limit (*contribution bases*), which are annually fixed and vary according with the professional category.

Pension formula: Fifteen years of contributions are needed to be entitled to receive a pension. A complete withdrawal from the labor force is also a requirement to start collecting the benefit. The initial amount is worked out by multiplying a *regulatory base* and a replacement rate. The *regulatory base* is a moving average of the *contribution bases* in the 15 years immediately before retirement (8 before the 1997 reform). The replacement rate depends on the age and the number of years of contributions. An individual receives a 100% of the *regulatory base* if he retires at the age of 65 (Normal retirement age, τ_N) having contributed for more than 40 years. It is possible to start collecting the pension at the age of 60 (Early retirement age, τ_m) under a 35% penalty on the regulatory base. This corresponds to a 7% (8% for workers with a short contribution record) annual penalty for bringing forward the retirement age.[5] There is also a penalty for insufficient contributions if the length of the working career is less than 35. In that case, a 2% reduction is applied to the *regulatory base* for every year the contribution record is below that number. The purchasing power of the initial benefit is kept constant according to the evolution of the Retail Price Index.

Minimum and maximum pensions: There are upper and lower limits on the pension benefit. The historical behaviour of both limits, which are annually fixed by the government, has been very different. The minimum pensions have grown at approximately the same rate as nominal wages over the last 15 years, while the maximum have been kept roughly constant in real terms during the same time interval.

[4]The existence of a variety of regimes is a distinguishing feature of the Spanish pension system from its very beginning. However, all recent reforms have featured significant efforts to reduce the dispersion in regulation, making the General Regime the cornerstone of the entire system. As a result, 73.9% of active workers in 2001 were already affiliated to this scheme, although still 45% of that year's pensions were formed according to the rules of alternative and/or pre-existing schemes.

[5]A minor change in the way the penalties are computed was introduced in January 2002. The new dispositions slightly reduce the early retirement penalties for individuals with very long contribution records.

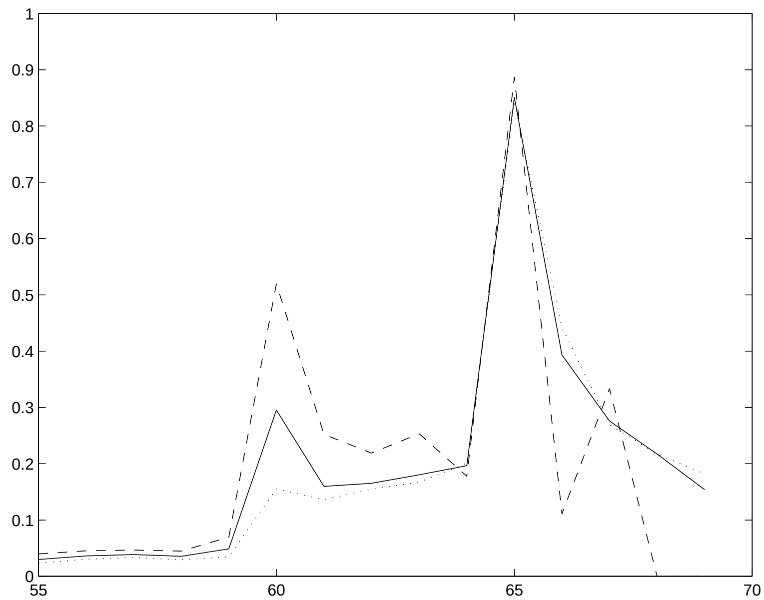

Figure 1: Retirement hazard by age: total population (-), workers receiving minimum pensions (- -) and workers who do not receive minimum pensions (·). Source: HLSS, 1995

2.2 Labor supply patterns of older workers

The labor supply of Spanish older workers is characterized by the following empirical regularities:

(F1) Sharp discontinuities in retirement hazard in both the *early* retirement age (60) and the *normal* retirement age (65).

(F2) Most (67.7% in 1995) early retirees are low income workers who are receiving the minimum pension complement.

(F3) "Working hours" do not react to changes in the effective contribution rates along the individual life cycle.

Most workers withdraw from the labor force either at the *early* retirement age or at the *normal* retirement age, as figure 1 makes clear. This is a very robust empirical pattern, shared by most countries with similar PAYG, Defined Benefit (DB) pension systems.[6] The composition of the hazard peaks according to the level

[6] Our data come from a 1995 sub-sample of administrative records from the Spanish Social Security (HLSS, described in Boldrin, Jiménez, and Peracchi (1999)), but virtually identical patterns can be found in any other available database (eg. the European Household Panel (ECHP), the Family Income Survey (EPF) or the Labor Force Participation Survey (EPA)). Across-countries

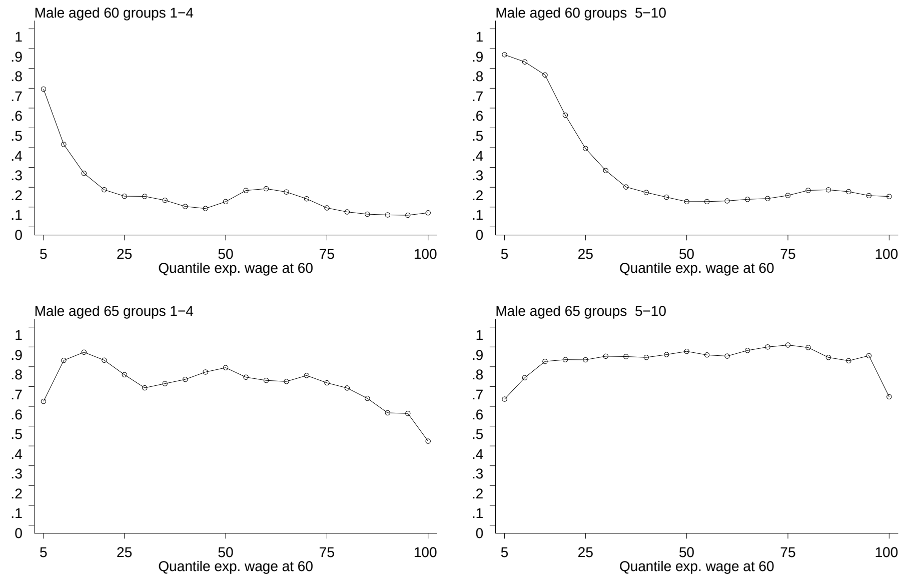

Figure 2: Retirement hazard at the ages of 60 (top panels) and 65 (bottom panels) for high (left panels) and low (right panels) educated workers, draw as a function of the wage level at the age of 60. The educational level is approximated by the social security contribution group. Source: HLSS, 1995 sample.

of the individual's labor income is analyzed in figure 2. This is done by constructing a non-parametric estimation of the retirement hazard at some selected ages, as a function of the level of labor income at the age of 60. We find that, while the probability of leaving the labor force is not affected by the salary level at the *normal* retirement age, there is a clearly decreasing pattern at the *early* retirement age. This pattern is basically independent of the individuals' educational achievement. This means that most early retirees are low income workers who qualify for a top-up of their pensions under the minimum pension scheme. As this event is observable in our sample, we can easily check its occurrence in our data. We find that 67.7% of the people who retire at the exact age of 60 are actually receiving the guaranteed minimum. It is also interesting to note that the retirement hazard at the age of 60 is 5 times larger for those who receive the minimum pension (see figure 1). Figure 3 displays a final piece of evidence about Spanish worker's labor supply. It shows that, in sharp contrast with the previous evidence on participation behavior, the profile of hours worked for a representative full time Spanish worker is smooth. There is no trace in the data of any discontinuity that could be attributed to the impact of the pension regulations.

comparisons of retirement hazards are presented in, for example, Gruber and Wise (1999) (for eleven developed countries) or Jiménez, Labeaga, and Martínez (1999) (for all OECD countries).

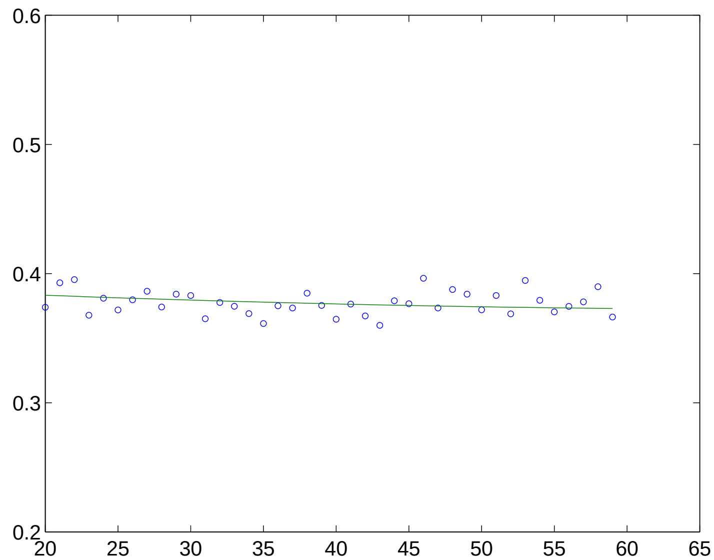

Figure 3: Life Cycle profile of hours worked (as a fraction of the individual time endowment, normalized to unity) for full time workers in ECHP, 1994.

2.3 The causal effect of pension rules on labor supply patterns

In this section we discuss whether the stylized facts F1 to F3 can be rationalized as the optimal replies of rational individuals to the incentives provided by the pension regulations. All discussion will be kept at an informal level (a formal treatment can be found in chapters 1 & 2 of Sánchez-Martín (2002)). This discussion provides the basic rationale for our main modelling choices.

Pension rules and retirement behavior

We review the impact of pension rules in retirement behavior by showing the distortions they create on the marginal benefits and costs of working. An individuals who keeps working at any age τ, has to face two marginal costs: a reduction in the amount of leisure time, and the foregone pension benefit (if he is old enough to be entitled to it). On the other hand, an individual who keeps working receives a salary and typically increases the pension benefit he is entitled to in the future. In Spain, this latter effect depends on two elements. Firstly, delaying retirement in the age range $\{\tau_m, \ldots, \tau_N\}$ reduces the early retirement penalty (and the insufficient contributions penalty, if the number of working years is lower than 35). Secondly, the *regulatory base* changes as current gross labor income substitutes for the value recorded 15 years before. Note that while the first element always results in a higher benefit, the second one may have the opposite effect. This is a direct consequence

Table 1: Effective contribution rates for a representative Spanish worker. We assume that the representative agent's life-cycle profile of income coincides with the median of the empirical distribution in ECHP94. We explore three cases, depending on the retirement age: τ= 55, 60 and 65.

τ=55		τ=60		τ=65	
age	Etax %	age	Etax %	age	Etax %
20	20.7	20	20.7	20	20.7
...	...	...	...	...	...
46	20.7	51	20.7	56	20.7
47	-64.5	52	-62.1	57	-58.9
48	-69.2	53	-66.7	58	-63.3
49	-74.2	54	-71.5	59	-68.0
50	-79.4	55	-76.6	60	-72.9
51	-85.0	56	-82.0	61	-78.1
52	-90.8	57	-87.7	62	-83.5
53	-97.0	58	-93.7	63	-89.3
54	-103.5	59	-100.0	64	-95.4

of the concavity of the life cycle profiles of gross labor income (figure 13 reproduces the profiles for the representative agents used in the model).

Keeping this in mind, it is not difficult to explain the age 65 peak in the retirement hazard (F1). It is the optimal answer to (1) the lack of an actuarial adjustment of pension benefits after the normal retirement age, (2) the drop in the *regulatory base* induced by labor income dynamics at such advanced ages and (3) the fact that the opportunity cost of the foregone pension relative to the salary is typically at its maximum at that age. This conclusion is supported by the results of a number of different studies.[7] Early retirement patterns are also easily rationalized as an artifact of the minimum pension mechanism. As the value of the minimum is completely independent of the individual characteristics, it entirely eliminates the incentives stemming from the pension formula. In particular, it increases the opportunity cost

[7]Boldrin, Jiménez, and Peracchi (1999) and Diamond and Gruber (1999) compute the accrual and tax rates generated by the pension rules in Spain and USA respectively, funding a strong discontinuity at τ_N in both countries. The optimal life-cycle behavior in presence of these incentives is calculated in chapter 2 of Sánchez-Martín (2002) for the Spanish case. The simulations there confirm that waiting till τ_N is optimal for most workers, with the exception of those in both tails of the labor income distribution. Finally, several structural econometric estimations have confirmed the contribution of these factors to generate the retirement behavior actually observed in the data. Jiménez-Martín and Sánchez-Martín (2003) is a reference for the Spanish case, while Rust and Phelan (1997) shows that including the details of the Health Insurance System is important to capture the magnitude of the peaks in the US.

of the foregone pension and wipes out the strong incentives to work associated with the early retirement penalties. As working an additional year does not increase the minimum pension, the best strategy for most affected workers is to leave the labor force as soon as the pension is first available (ie, at the early retirement age). In general, we conclude that the empirical regularities F1 & F2 can be explained as the optimal reply to the non-linearities induced by the pension rules on the individuals' inter-temporal budget constraint.

Pension rules and hours worked

While data reveal that participation decisions are highly sensitive to the incentives implicit in the pension rules, the evidence on its impact on the "hours" worked is much weaker. A good example of this unresponsiveness is found when analyzing the sensitivity of hours worked to the life-cycle changes in *effective* contribution rates.[8] In countries with short averaging periods in the pension formula the *effective* contribution rates can fluctuate dramatically over the life cycle (see Kenc and Perraudin (1997a)). This is the case for a representative Spanish worker, as the figures in table 1 make apparent. Regardless of the retirement age, the *effective* rates are substantially negative for all the ages included in the *regulatory base*. This should represent a strong incentive to increase the labor supply in the years immediately before retirement. However, there is no trace of such a behaviour in the Spanish data (figure 3). This could reflect the existence of institutional constraints that prevents workers from implementing their optimal life cycle profiles of hours worked. Legal limits in the number of overtime hours and other restrictive dispositions stemming from the collective bargaining (at the firm or sector level) are to blame for this rigidity in the Spanish labor market.

2.4 Rationalizing our main modelling choices

Our conclusion form the empirical and theoretical evidence reviewed in this section is that the reforms analyzed in this paper are most likely to alter the effective age of retirement (as they substantially modify the implicit incentives, and people seem to be very sensitive to those incentives). Taking into account that the generosity of the Spanish pension system fluctuates with retirement age, we can only conclude that we need an endogenous retirement age to give a sensible answer to the question in this paper.[9] Moreover, to reproduce the empirical patterns F1 & F2 we clearly need a heterogeneous agent model (with workers differing in their labor income process) and a detailed reproduction of the main rules determining the value of the pension

[8]The *effective* contribution rates can be define as the variation in the life-cycle income generated by a marginal change in the number of hours worked.

[9]Early retirees are substantially more expensive for the public system than normal retirees. This can be assessed by comparing the internal rates of return obtained by the contributions paid during the working years. Chapter 2 in Sánchez-Martín (2002) is an example. That is also the case for the representative agents implemented in our model, as the results in table 5 make clear.

benefits in Spain. Regarding F3, there is no doubt that the reforms we study in this paper are due to modify the incentives on the intensive margin of labor supply, ie the hours worked. However, there is no reason to assume that the institutional constrains that have blocked the transmission of those incentives to actual behavior in the past are going to be weaken in the future. Keeping this in mind, we believe that the simplest and most coherent modelling strategy for the hours worked is to directly plug into the model the empirical life-cycle profiles, and to keep them exogenously fixed all along the simulations.[10]

3 The model

The model consists of overlapping generations of agents that live up to I periods. A period in the model stands for one year of real time, which we denote by t when referring to calendar time and by i when referring to individual age. The cohort the individual belongs to is denoted by u. We identify the first period (i=1) in the model with the age of entrance into the labor market. At that time individuals are classified according to their educational attainment in one of J possible categories (denoted by $j \in \mathcal{J} = \{1, \ldots, J\}$). The description of the model demands substantial notation which, for easy reference, is collected in tables 2 (variables) and 3 (parameters). As a general rule individual variables are written in lower case with a couple of subscripts and a superscript representing age, education and calendar year. Aggregate variables are denoted with capital letters and have just one superscript indicating calendar time.

3.1 Demographic Model

We model a one sex population were individuals are classified according to their birth place as "Natives", N^t, or "Migrants", M^t. Unfortunately, the absence of reliable statistical information forces us to reduce the differences between the two groups to a minimum. The number of people born at t is determined by the vector of age specific fertility rates $\{\theta_i^t\}$ $(f_0 \leq i \leq f_1)$:

$$N_1^t = \sum_{i=f0}^{f1} \theta_i^t \, N_i^{t-1} + \sum_{i=f0}^{f1} \tilde{\theta}_i^t \, M_i^{t-1} \tag{1}$$

where f_0 and f_1 stand for the lower and upper fertile ages and $\tilde{\theta}_i^t$ captures the (potentially) different fertility of migrants.

[10]Ideally, it would be better to work with an endogenous hour decision in a model including all the relevant institutional constraints. This task, however, far exceeds our goals in this paper. It is also interesting to note that although most previous papers have modelled an endogenous hours decision, they have also included the assumption that individuals are ignorant of the relevant legislation.

INDIVIDUAL			
Retirement age	τ_j	Initial pension	$b(\tau, u)$
Accumulated assets	$a^t_{i\,j}$	Consumption	$c^t_{i\,j}$
Gross labor income	$il^t_{i\,j}$	Gross pension income	$ib^t_{i\,j}$
Life-cycle utility	$V_j(\tau, u)$		
AGGREGATE			
Public Policy		**Macroeconomic**	
Revenues form bequests	BI^t	Product	Y^t
Fiscal Income	FI^t	Capital stock	K^t
Lump-sum tax	φ^t	Labor Supply	L^t
Minimum pension	bm^t	Pension Expenditure	PP^t
Public Consumption	CP^t	Pension System Deficit	DSS^t
Technology index	A^t		
Population		**Prices**	
Total	P^t	Wage	w^t
Natives/Inmigrants	N^t, M^t	Rental capital	r^t
Age distribution	$\mu^t_{i,j}$		

Table 2: Model notation: endogenous variables. List of endogenous variables in the model. The counters used are: $i \in \{1, \ldots, I\}$ for individual age; $t \in \mathcal{T}$ for calendar year and u for year of birth (which identify the individual cohort).

Population		**Public policy**	
Age specific fertility rate	θ^t_i	Pay-roll tax rate	ς
Conditional survival probability	hs^u_i	Number of years in benefit base	D
Immigrant flows	$F^t_{i,j}$	Early entitlement age	τ_m
Population growth rate	n^t	Normal retirement age	τ_N
Leisure	l_i	Early retirement penalties	$\alpha(\tau)$
Efficiency labor units	$\varepsilon_{i\,j}$	Minimum pension (% y)	b_m
Distribution by education	ω_j	Public Consumption (% Y)	c_p
Individual		**Technology**	
Relative risk aversion	η	Depreciation rate	δ
Pure time preference	β	Capital share (on National Income)	ζ
Leisure preference	σ	Exogenous productivity growth	ρ

Table 3: Model notation: parameters. List of parameters defining the individual preferences and the economic and demographic environment.

Figure 4: Simulation schedule: TD= Demographic Transition, CDP= Convergence of population dynamics, CEE= convergence to the economy steady state, EE= Steady State.

Mortality dynamics for the members of a specific cohort u is captured by the vector of age-conditional survival probabilities $\{hs_i^u\}_{i=1}^I$. After rewriting in calendar-time terms and denoting the net immigrants flows by F_i^t, the after-birth population dynamics for both natives and migrants is given by:

$$N_i^t = hs_i^{t-i+1}\, N_{i-1}^{t-1} \qquad M_i^t = hs_i^{t-i+1}\, M_{i-1}^{t-1} + F_i^t \qquad 1 < i \leq I \tag{2}$$

Combining (1) and (2), the entire population dynamics can be embedded in a linear system of difference equations in the vectors $\overline{P}^t = (\,\{N_i^t\}\,,\,\{M_i^t\}\,)$ and $\overline{F}^t = \{F_i^t\}$:

$$\overline{P}^{\,t+1} = \Gamma^t\, \overline{P}^{\,t} + \overline{F}^t \tag{3}$$

Figure 4 displays how the simulation unfolds in calendar time. We assume non-stationary demographic patterns in the initial stage of the simulation, reflecting a recovery in the fertility rates and a smooth reduction in mortality. Eventually both processes stabilized and all the new cohorts show the same patterns of mortality and fertility. We assume this happens in t^1, long after the starting of the simulation. We further simplify the demographic process by assuming that, after t^1, the flows of workers from abroad eventually die out. This means that in t^2 (I periods after t^1) the population dynamics is simply given by

$$\overline{P}^{\,t+1} = \Gamma\, \overline{P}^{\,t} \tag{4}$$

This simplifications have a very small quantitative impact in the performance of the economy in the short run (within a 50 years horizon). Finally, we truncate the model and assume that both the population and the economy have converged to a (balanced growth) steady state in t^3.

3.2 Economic Model

It is a highly stylized representation of a closed economy (only flows of workers from abroad are permitted). Individuals are endowed with one unit of time per period, which can be enjoyed as leisure or can be traded in a labor market to produced (jointly with capital) a consumption good. We assume an operative credit market, but with some restrictions (we do not allow individuals to borrow against future pension income). At the aggregate level the economy is deterministic while at the micro level individuals are uncertain about the length of their life. There is no insurance market for this risk, as annuity markets are closed by assumption. We assume that the public sector entirely confiscates the savings (or debts) left by people who die early. Under these conditions, every period output is obtained by combining the stock of capital saved by the individuals who survive form the previous period and current workers' labor supply.

3.2.1 The Public Sector

The main role played by the Public Sector is to run a PAYG-DB social security system. The revenue of the system comes from the payroll taxes paid by active workers. They are collected as a fixed proportion, ς, of current labor earnings. After a complete withdrawal from the labor force, those workers who have reached the *early retirement age*, τ_m, can claim the pension benefit. The *initial* pension for an individual belonging to cohort u and retired at age τ is computed according with the following expression.[11]

$$b(\tau, u) = \alpha(\tau) \left(\frac{\sum_{e=\tau-D}^{\tau-1} il_e^{u+e}}{D} \right) \tag{5}$$

where il_i^t stands for the gross labor income at age i and calendar year t. The formula combines a *regulatory base* (an average of the gross labor earnings obtained during the D years immediately before τ) and a replacement rate $\alpha(\tau) \leq 1$ that penalizes retirement before the *normal* retirement age, τ_N :

$$\alpha(\tau) = \begin{cases} \alpha_0 < 1 & \text{if } \tau < \tau_m \\ \alpha_0 + \alpha_1(\tau - \tau_m) < 1 & \text{if } \tau \in \{\tau_m, \ldots, \tau_N - 1\} \\ 1 & \text{if } \tau \geq \tau_N \end{cases} \tag{6}$$

This *Initial* pension is kept constant in real terms as the individual ages, although it can be increased in case the minimum pension bm^t catches up with it. This may happen because bm^t is annually determined by the government, and the standard practice has been to slightly increase its real value over time. Taking this into account, the pension income for an individual of age i in t and retired at age τ is given by:

$$ib_i^t(\tau) = max\{bm^t, b(\tau, t - i + 1)\} \tag{7}$$

[11]We abstract from some minor pieces of the Spanish pension regulation, in an attempt to get a sharper characterization of the effects of the most determinant ones. In particular, we omit the floor and ceilings on covered earnings, the maximum pensions and the penalties for insufficient contributions.

The Public Sector also incurs some consumption expenditure CP^t and runs a neutral fiscal system. The Annual fiscal revenue is obtained from the full confiscation of (involuntary) bequests and from a system of lump sum taxes.[12] All fiscal revenue is applied to finance public consumption (which does not increase personal utility) and to cover any potential social security deficit. The policy rule is, then, to fix the anual per-capita tax φ^t in such a way that *the whole* public budget balances.

3.2.2 The firms

We assume a neoclassical technology $F(K, L)$ with constant returns to scale, no adjustment cost and exogenous labor-augmenting technological progress (represented by the index A^t). The rate of productivity growth, ρ, is constant. Finally, we assume that this technology is run by profit-maximizing competitive firms.

3.2.3 The Households

The productive capacity of the individual (unitary) time endowment changes with age, calendar time and educational group. This is captured by the amount of effective labor units $\varepsilon^t_{i\,j}$ owned by an individual of educational group j and age i at calendar time t. We abstract from schooling and labor market entrance decisions, and simply impose an *ex ante* exogenous distribution of educational types, ω_j. This distribution remains unchanged across cohorts. Besides the difference in life-cycle productivity, people of different educational type also differ in the life-cycle profile of hours worked, $\{1 - l_{i\,j}\}$. By the reasons discussed in section 2.4, this fraction of time allocated to market activities is exogenously fixed.

Agents in the model maximize their expected lifetime utility by taking two types of decisions: the inter-temporal allocation of consumption and a "once and for all" retirement age.[13] Formally, individuals of type j belonging to cohort u choose a retirement age, τ^u_j, and the vectors of life-cycle consumption and accumulated wealth, $\{c^{u+i-1}_{i\,j},\ a^{u+i-1}_{i\,j}\}^I_{i=1}$, that maximize the life-cycle utility: the sum of the expected, discounted utility flows stemming from an standard period utility function:

$$V_j(\tau, u) = \sum_{i=1}^{\tau-1} \beta^{i-1}\, s^u_i\ u(c^{u+i-1}_i, l_i) + \sum_{i=\tau}^{I} \beta^{i-1}\, s^u_i\ u(c^{u+i-1}_i, 1).$$

β is the time preference parameter and s^u_i is the unconditional survival probability to age i for a member of the cohort u. While the individual is active in the labor market, the relevant budget constraint is:

$$c^{u+i-1}_{i\,j} +\ a^{u+i}_{i+1\,j} = (1 - \varsigma)\, i l^{u+i-1}_{i\,j} + (1 + r^{u+i-1})\, a^{u+i-1}_{i\,j} - \varphi^{u+i-1} \qquad (8)$$

[12]The simulation of the model under a proportional income tax generates very small changes in the quantitative results. The version without fiscal distortions is, however, much more convenient, as it allows to isolate the effects of any pension reform.

[13]"Reverse retirement" is always suboptimal for the representatives agents (by education type) that populate the model.

where $il^t_{i\,j}$ stands for his/her gross labor income at age i and calendar time t. This is computed as the product of the number of efficiency labor units provided and their current market value: $il^t_{i\,j} = w^t\, \varepsilon^t_{i\,j}\,(1 - l_{i\,j})$. After retirement, the relevant budget constraint is

$$c_i^{u+i-1} + a_{i+1}^{u+i} = ib_{i\,j}^{u+i-1}(\tau) + (1 + r^{u+i-1})\, a_i^{u+i-1} - \varphi^{u+i-1} \tag{9}$$

The pension income at age i in t, $ib^t_{i\,j}(\tau)$, can be recovered from expressions (5) to (7). Finally, individuals are not allowed to borrow from their future pension flows, which is equivalent to a nonnegative constraint on the value of the stock of assets at any age after retirement. The techniques applied in the solution of this problem are described in the appendix A.

3.2.4 The Equilibrium.

An *equilibrium path* over a time interval $\mathcal{T}$ consists of the following objects:

- Population aggregates $\{N^t, M^t, P^t, F^t\}$ and population distributions by age and education, $\mu^t_{i\,j}$ for all $\quad i \in \mathcal{I} \quad j \in \mathcal{J} \quad t \in \mathcal{T}$
- Assignments of consumption, savings and working hours $\{\, c^t_{i\,j},\ a^t_{i\,j},\ 1 - l^t_{i\,j}\}$ for all cohorts alive in $t \in \mathcal{T}$ and all education types $j \in \mathcal{J}$. [14]
- Inputs employed by the competitive firms $(K^t, L^t) \quad t \in \mathcal{T}$
- A Public Policy $\{\varphi^t, bm^t, CP^t\} \quad t \in \mathcal{T}$.
- A price system: $\{r^t, w^t\} \quad t \in \mathcal{T}$

such that the following properties apply $\forall \quad t \in \mathcal{T}$:

1. Endogenous population dynamics

   Population aggregates and distributions are generated by eq. (3) and (4), given exogenous profiles for fertility, mortality and flows of immigrants.

2. Individual Rationality.

   Individual assignments are optimal given the price system and the public policy.

3. Competitive prices.

$$r + \delta = \frac{\partial F}{\partial K}(K^t, L^t) \qquad w^t(1 + \varsigma) = \frac{\partial F}{\partial H}(K^t, L^t)$$

[14] Note that the working hours depend on the retirement ages τ^u of cohorts alive at t.

4. Factor markets clearance.

   The capital and labor effectively employed by firms come form the aggregation of individual savings and labor supply:

$$L^t = A^t\, H^t \qquad H^t = \sum_{j=1}^{J} \sum_{i=1}^{\tau_j - 1} P_{i\,j}^t\, \varepsilon_{i\,j}\, (1 - l_i) \qquad K^t = \sum_{j=1}^{J} \sum_{i=1}^{I-1} P_{i\,j}^t\, a_{i\,j}^t \tag{10}$$

5. Public budget's balance.

$$FI^t(\varphi^t) = DSS^t + CP^t$$

   where the fiscal income, FI^t, and the income from bequest, BI^t, take the form:

$$FI^t(\varphi^t) = \varphi^t P^t + BI^t \qquad BI^t = \sum_{j=1}^{J} \sum_{i=1}^{I-1} (1 - hs_{i,j}^{t-i})\; P_{i\,j}^{t-1}\; a_{i+1\,j}^{t-1} \tag{11}$$

   the social security deficit is given by

$$DSS^t = PP^t - \varsigma w^t H^t \qquad PP^t = \sum_{j=1}^{J} \sum_{i=\tau_j}^{I} P_{i\,j}^t\; ib_{i\,j}^t(\tau_j) \tag{12}$$

   where PP^t stands for the aggregate pension expenditures.

6. Aggregate feasibility

$$Y^t + (1 - \delta)\, K^t + BI^t = K^{t+1} + BI^{t+1} + \sum_{j=1}^{J} \sum_{i=1}^{I} P_{i\,j}^t\, c_{i\,j}^t + CP^t \tag{13}$$

Following Auerbach and Kotlikoff (1987) the "Equilibrium" includes three particular forms of the previously defined object: a path along the time interval $\mathcal{T} = \{t^0, \ldots, t^3\}$ (see figure 4), that converges to a final steady-state, and an initial steady state from where all the initial conditions at the time the simulation starts are taken.[15] The steady states are particular cases of the *equilibrium path* defined

[15] The set of initial conditions depends on the cohort. For very old individuals at t_0 (which are already retired when the simulation starts) the initial conditions include the initial pensions and their stock of assets at t_0. For cohorts of active workers close enough to retirement at the starting date (ie older than $\tau^u - D$), some of the salaries included in the pension formula's averaging period are already fixed. Again, the stock of assets at t_0 is also predetermined. Finally, for the rest of the individuals alive when the simulation starts, only the current stock of assets is already fixed. The more natural way to form those initial conditions is by direct measurement form empirical data. Unfortunately, the available Spanish databases do not include reliable information on the distribution of wealth by age and education. In these circumstances, we adopt the standard solution in the literature: we take them from an initial steady state calibrated to reproduce the economic conditions prevailing when these conditions came into existence.

above, were the population is stable and grows at a constant rate; aggregate variables grow at a fixed rate given by the sum of the population and productivity growth rates; the *per capita* variables and wages grow at the productivity growth rate and the interest rate is constant.

4 Calibration

We calibrate the previous section's model according to the following objectives: **(i)** to set up an immigration and demographic scenery consistent with the historical Spanish patterns and to ensure that the initial equilibrium reproduces: **(ii)** the basic regulations of the Spanish pension system, **(iii)** the key ratios of the Spanish National Accounts, **(iv)** the average retirement age and the basic qualitative features of retirement behavior in Spain, and **(v)** the life cycle profiles of productivity and hours worked by educational level. Targets **(i)** to **(iii)** directly stem from the question we try to answer in this paper. Target **(iv)** reflects the importance of retirement for the financial balance of the pension system. Finally, the interaction between pension rules and individual labor income processes is a key determinant of retirement decisions. That is the rationale for our final calibration target **(v)**.

4.1 Immigration and Demographics

We assume that individuals start their life in the model when they are 20 years old and that their maximum possible length of life is 100 (ie , I=80 as a period in the model stands for one year of calendar time). We also assume that demographic patterns are non stationary between $t_0 = 1995$ and $t_1 = 2050$. The recovery in fertility is implemented through parallel shifts in the age specific fertility rates θ_i. The pace of these shifts is controlled in such a way that the implied total fertility rate is 1.7 and 1.75 in 2025 and 2050 respectively.[16] This process is illustrated in the upper panels of figure 5. We also make the age-conditional survival probabilities $\{hs_i\}$ goes up cohort by cohort. This increase is parameterized in such a way that the cohort's life expectancy rises linearly from the 1995 value (77.2 years) to 80.4 years in 2050. Again, figure 5 shows the simulated process of mortality reduction.

As far as immigration is concerned, we reproduce the initial stock and age distribution of foreigners living in Spain, at the time the simulation starts.[17] We assume the age distribution of the future flows to be constant over time, while their size is fixed according to 2001 INE projections (lower panels of figure 5). This projection draws a scenery of very substantial immigration flows: the share of immigrants in total population triples over our 50 years simulation horizon. Unfortunately, the

[16] This projection reproduces Spanish National Statistics Institute INE (1995) intermediate scenery, and is a good example of the figures usually found in the fertility literature.

[17] We use INE 90/91 Census data completed with the entrance flows in the interval 91/94, taken from INE Immigration Survey (Encuesta de Migraciones). The immigration projections are taken form "Proyecciones de la población en España", available from INE's web site.

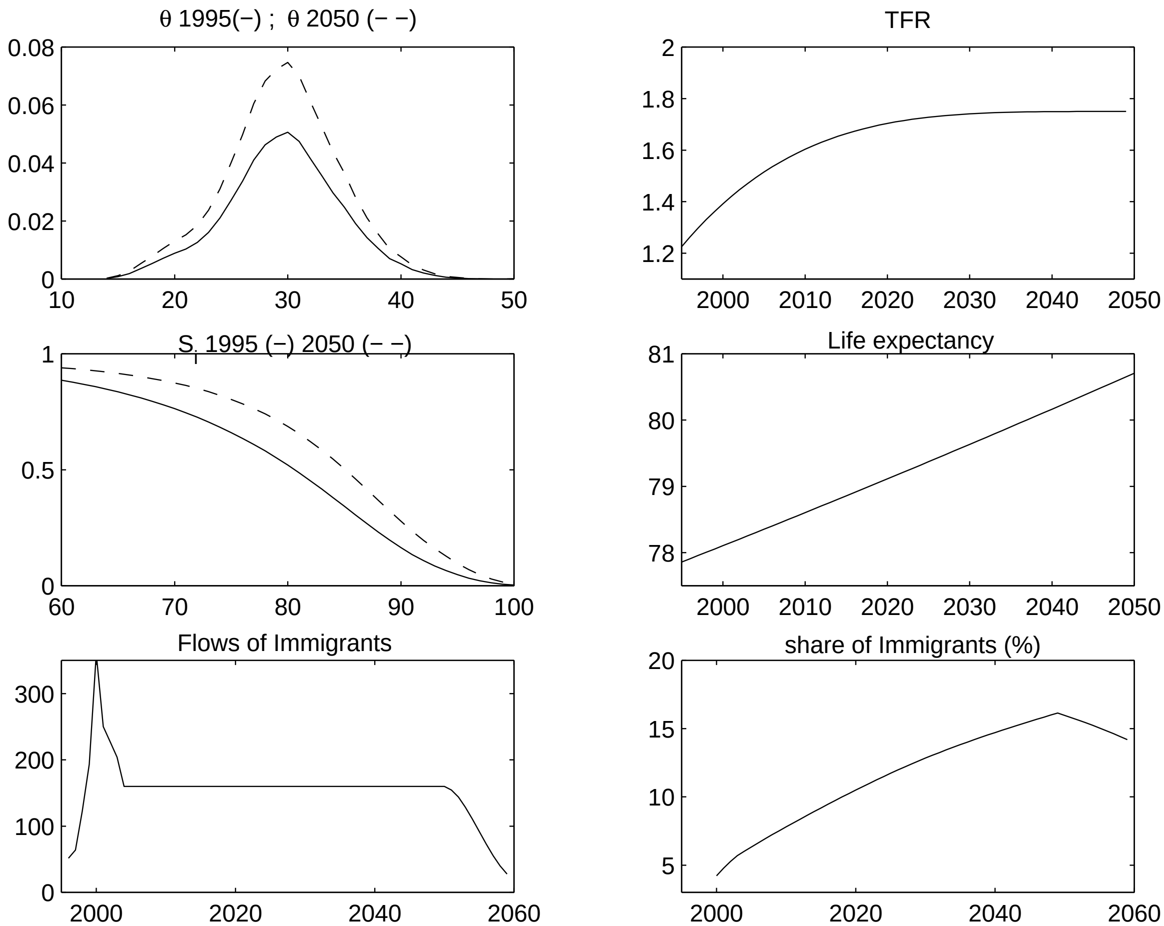

Figure 5: Demographic projections. Upper panels: 1995 age-specific fertility rates $\{\theta_i\}$ and our projection for 2050 (left); and the implied total fertility rate path (right). Intermediate panels: Age-specific survival probabilities $\{S_i\}$ in 1995 and our projection for 2050 (left); and the associated life expectancy time series (right). Bottom panels: size of the simulated immigrants flows (left) and the implied immigrant share on total population (right).

calibration of immigrants cannot go any further than this, as the absence of reliable empirical data makes it impossible to account for the differences in earnings or demographic patterns.[18]

All economic initial conditions at t_0 come from a steady state, which includes a stationary population. This is characterized by a constant population growth rate and a fixed curve of age-specific survival probabilities. The figures actually implemented are the average Spanish population growth rate along the time interval 1970-1995 (n=0.0571%) and the vector of survival probabilities reported in INE mortality tables for 94/95.

4.2 Economic model

4.2.1 Functional forms and parameters

All individuals in the economy share the same period utility function: a separable CES function, with unitary elasticity of substitution, $u(c_i, l_i) = log(c_i) + \sigma\, log(l_i)$. We confine ourselves to the logarithm case is order to guarantee that all discrete decisions are constant in the final steady state, in spite of the presence of exogenous technological growth.[19] Therefore, the individual preferences are fully specified by selecting concrete values for σ and β.

Under Labor Augmenting technological growth, the age-specific profiles of efficiency units $\{\varepsilon_{i\,j}^{u+i-1}\}_{i=1}^{I}$ specializes to a unique life cycle productivity profile by educational type, $\{\varepsilon_{i\,j}\}_{i=1}^{I}$, which is shifted upwards with calendar time by the technological growth. In contrast, we consider a constant age profile of hours worked by educational type for all cohorts. Both dimensions are parameterized with the help of quadratic curves, which means that two sets $3 \times J$ parameters are to be fixed. The distribution by educational type itself, ω_j^t, is assumed to be constant both within the life o a cohort and across cohorts.

The aggregate technology is represented with a standard Cobb-Douglas production function, with capital and efficient labor units ($Y = K^{\zeta}\, L^{1-\zeta}$) as its arguments.[20] We assume there are no adjustment costs, a constant rate of capital depreciation, δ and a constant productivity growth rate, ρ.

To describe the government policy in our model we must specify the parameters of the pension formula ($\tau_m, \tau_N, \alpha_0, \alpha_1$ and D), the contribution rate ς and the

[18]It is also impossible to have data on the average assets that immigrants of different ages are taking with them when getting into Spain. This force us to make an arbitrary assumption on this variable. For the sake of computational simplicity we assume they hold a similar amount of accumulated assets as that hold by their Spanish counterparts of the same age.

[19]See appendix B1 in Sánchez-Martín (2002). Fortunately, the implemented value is very close to several econometric estimations based on this life cycle model (eg. Hurd (1989) and specially Jiménez-Martín and Sánchez-Martín (2003) for the Spanish case).

[20]Factor income shares in Spain does not seem to have been constant in the past years (see Boldrin, Jiménez-Martín, and Peracchi (2001), pg. 34 to 37). Therefore, this functional form is chosen to ease the comparability with the previous literature.

Table 4: Alternative institutional environments. Pension formula parameters in the different simulations: base simulation, 1997 reform (R97), extension of 1997 reform (R97+), delay in the normal retirement age ($\tau_N = 67$) and simultaneous implementation of R97+ and $\tau_N = 67$ (Double).

	Base	R97	R97+	$\tau_N = 67$	Double
τ_N	65	65	65	67	67
τ_m	60	60	60	60	60
α_0	0.6	0.65	0.65	0.51	0.51
α_1	8%	7%	7 %	7 %	7 %
D	8	15	30	15	30

functions determining the annual values of the minimum pension and public consumption. In the latter cases we assume very simple linear rules: we make the minimum pension proportional to the average productivity ($bm^t = b\_m\, y^t$), while public consumption is assume to be a constant fraction, c_p, of the aggregate product.[21]

4.2.2 Calibration targets and parameter choices

Our previous modelling choices imply that we must select specific values for a total of 34 parameters before we can compute the equilibrium of our model.[22] In this section we show how these values are assigned in an attempt to reproduce our economic calibration targets **(ii)** to **(v)**.

- **(ii)** Public pension system

  The values assigned to the parameters of the pension formula and the contribution rate reproduce their empirical counterparts in the General Regime (RGSS), before the changes introduced in 1997 (see the first column of table 4). The parameter determining the *level* of the minimum pension b_m is fixed to target the minimum-to-average pension ratio (0.77).[23]

[21] The historical growth rate of minimum pensions is slightly lower than the productivity growth rate (see section 9.2 in Boldrin, Jiménez-Martín, and Peracchi (2001)), and very close to the average growth rate of salaries. In our model these three growth rates should coincide to guarantee that all discrete decisions are constant in the steady state. Note that, in our formulation, the short run growth rate of the minimum pensions fluctuates depending on the capitalization of the economy.

[22] This number depends on the number of educational levels considered. As described bellow, the optimal number in our case is J=3. Therefore, we have 2 parameters describing household preferences, 20 for the earnings and hours processes, 3 for the aggregate technology and 9 for the government policy.

[23] 0.77 is the minimum pension to average pension ratio in the time interval 80/95 for early

- **(iii)** Average retirement age.

  We fix the value of σ in such a way that the average retirement age in the initial steady state is as close as possible to the empirical value (62.98 in 1978-1995 according to EPA data). With a value of 0.2, we find that the low educated workers early retire, while high and average educated workers wait till the normal retirement age (third column in table 5). This behavior implies an average retirement age in the model of 63.69, just a little higher than the value observed in the data.

- **(iv)** Life cycle profiles by education.

  All our information about income, hours worked and education comes from the 1994 cross section of the ECHP. In this database we can precisely identify up to three educational types: High (j=1), Average (j=2) and Low (j=3) educated workers. Their empirical distribution is presented in the second column of table 5.[24] The productivity and hours profiles for each educational type have been estimated from data on gross labor earnings, hours worked and employment rates (see appendix B). The results can be appreciated in figures 13 and 14 (again, in appendix B).

- **(v)** Macroeconomic aggregates.

  We choose β and δ to target the averages of the capital to output ratio and investment to output ratio during our calibration interval 1970-1995. The government expenditure to output ratio is directly imposed through the parameter c_p. Similarly, the capital income share is directly imposed by fixing ζ. Finally, we take the average growth rate of *per capita* consumption as the exogenous rate of productivity growth, ρ. The macroeconomic scenario resulting from these choices is shown in table 6.[25]

4.2.3 Non-calibrated dimensions

In this section we evaluate the performance of the model in two dimensions that have not been targeted in the calibration process. In first place, figure 6 compares the retirement hazard in the model with its empirical counterpart. From the graph

retirees with a dependent spouse.

[24] The educational distribution has been remarkably non stationary in the last decades. In order to reproduce the average behavior along our calibration interval, we include in the model the distribution for the cohorts born between 1955 and 1975 (ie. individuals age 40 in 1994 or younger).

[25] The labor income share is taken from Puig & Licandro. The figure for the stock of capital is the 70/95 average of the estimation in the Fundación BBV database "Sophinet" , available at: < *http://bancoreg.fbbv.es/sophinet/general/casa.html* >. All the other figures are 70/95 averages of the correspondent time series from the Spanish National Accounts (CNA86).

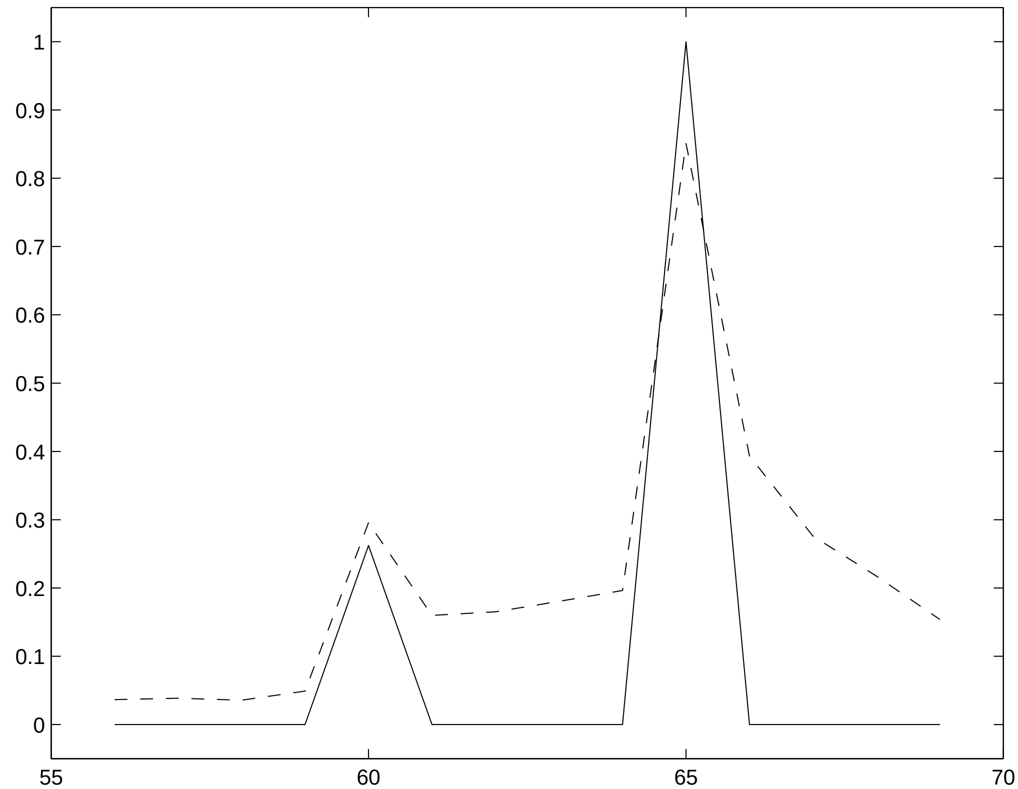

Figure 6: Retirement hazard in the initial steady state (-) and in the data (- -) HLSS-95

Education	ω_j	τ_j	$J_j(\tau)$	$\bar{t}_j(\tau)$	IRR_j	PP_j/Y %
High	24.6	65	-	88	2.17	5.60
Average	49.2	65	80	89	1.80	6.18
Low	26.2	60	60	87	3.16	3.78

Table 5: Intra-generational behavior in the initial equilibrium. Empirical distribution by educational type, ω_j, and optimal behavior in the initial equilibrium: optimal retirement ages τ_j, starting binding age for the minimum pensions $J_j(\tau)$; optimal binding age for the borrowing constraint $\bar{t}_j(\tau)$, internal rates of return for social security contributions, IRR_j, and share of the pension expenditure PP_j/Y- all of them by educational type.

Table 6: Macroeconomic calibration targets and parameter choices. Basic macroeconomic ratios for the 1970-1995 Spanish economy in the National Accounts, CNA86, and their calibrated counterparts in the model, along with the implemented parameter values.

	data	model	parameters
$rK/Y\%$	34.7	34.7	$\zeta = 0.347$
K/Y	2.57	2.59	$\beta = 0.983$
$I/Y\%$	23.6	23.4	$\delta = 0.064$
$CP/Y\%$	13.3	13.3	$c\_p = 0.133$
$\Delta lnC\%$	2.12	2.12	$\rho = 2.12$

and from the information in table 5 we conclude that the model approximately reproduces the stylized facts of retirement in Spain: the spikes at the *early* and *normal* retirement ages and the pattern of early retirement of low income workers (low educational level in the model) induced by a generous minimum pension scheme. In second place, table 7 shows a comparison between the aggregate levels of the pension system in the model and in the data. The model clearly overstates the magnitude of the system's revenues and expenditures.[26] Several different elements are to be blamed for this result. Firstly, there is a significant number of old age pensions computed according to the rules of other regimes (self employed, farmers, public servants) or of schemes that are no longer in operation (SOVI). In most cases, these excluded schemes have lower pension-to-income and contribution-to-income ratios than that in the General Regime. Furthermore, even within the General Regime, there exists some rules that break the strict link between income and pensions or contributions that we have in the model. The ceilings on pension benefits and contributions are best exponents of those rules. This link is also broken in the case of workers with short professional careers (less than 15 years), which do not qualify to receive a pension. Finally, the discrepancy between the stationary population distribution underlying the steady state and the actual, non stationary distribution also contributes to the observed discrepancy. As a general rule, it is clear than all the model predictions in terms of the pension system's *levels* must be taken with great care. We must bear in mind, however, that our basic question here is not directly

[26]The figures come from the "Cuentas Integradas de Protección Social" in *Anuario de Estadísticas Laborales-1999*, and refer to 1998. The discrepancy is even higher if the 89/97 average figures are considered (expenditures and contributions are 8.3 and 9.7 % of output). End of period figures are, however, more significant, as they present a system in a more advanced state of maturity. This is important, as the Spanish pension system is still converging to a unified structure from a variety of disperse regimes. And what we want to test in this paper is the capacity of that final structure to cope with the population aging.

Table 7: Public pension system's indicators. Performance of the model in some non-calibrated dimensions related to the pension system's *levels*: share of pensions affected by the minimum pension mechanism ($\%\,bm$), pension expenditure to output ratio, PP/Y; contribution to output ratio, COT/Y; and deficit to output ratios, DSS/Y.

	$\%\,bm$	PP/Y	COT/Y	DSS/Y
Data	0.32	11.7	14.62	-2.92%
Model	0.44	15.56	18.48	-2.91%

related to the system's levels but to its *relative* performance with and without the reforms.

5 Findings

We start the review of our simulations results by presenting the demographic projection underlying all of them in section 5.1. We then discuss the economic results, starting in section 5.2 with a brief review of the properties of our base simulation. It represents a forecast of the future evolution of the system in absence of any legislative reforms. In section 5.3 we describe the two basic reform strategies explored in the paper. The section finishes in section 5.4 with the discussion of the effects of the several reforms explored.

5.1 Population projections

In spite of our optimistic assumptions about the pace of fertility recovery and the size of immigration flows, population is eventually due to decrease. However, immigration flows are intense enough to postpone this event till 2038, as can be seen in the left upper panel of figure 7. The number of the elderly increases all along the simulation, peaking at 12 millions in 2045 and slightly decreasing afterwards. The size of those in working ages, in contrast, reaches its maximum in 2011 and decline steadily from that date onwards (right upper panel of fig. 7). Driven by these two simultaneous forces, the total dependency ratio increases from around 0.6 at the beginning of the simulation to a figure (0.94) quite close to one dependent person per worker in 2050 (left bottom panel of fig. 7).[27] This dramatic change in the age distribution of the population can be best appreciated by comparing the population

[27] The *total* dependency ratio is constructed by adding the number of people under 20 and above 65 and dividing it by the number of people between 20 and 65. The *old* age dependency ratio only include people over 65 in the numerator of the ratio.

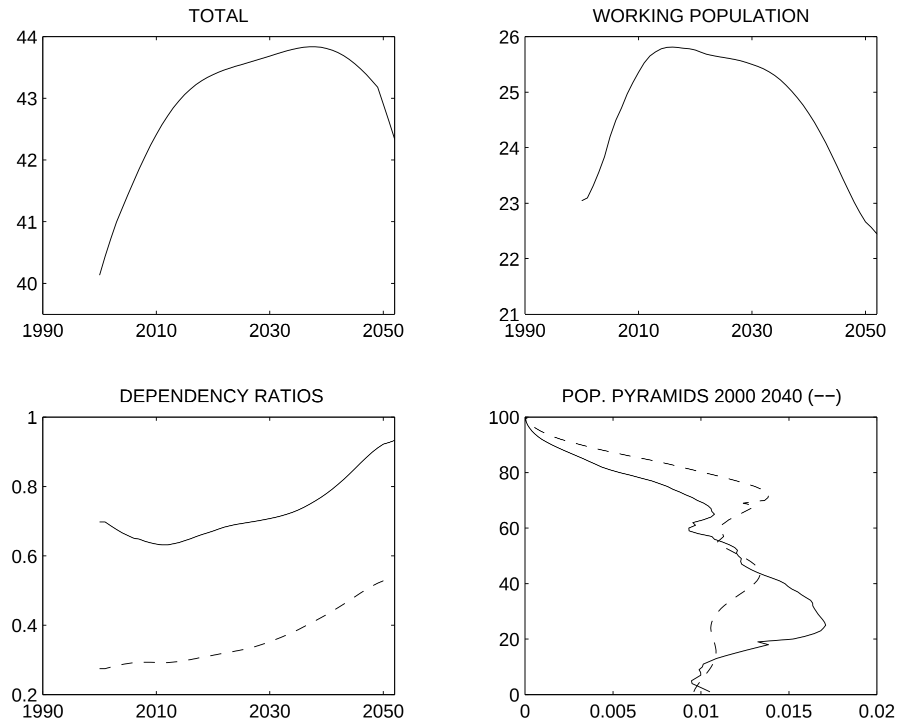

Figure 7: Population Projections: total and working population (upper panels); Total (-) and old age (- -) dependency ratios and population pyramids in 2000 (-) & 2040 (- -) (lower panels).

pyramids in different years. Such a comparison is shown in the right bottom panel of fig. 7 for 2000 and 2040.

5.2 Base simulation

In the base simulation we compute the equilibrium path and the final steady state of our model economy when the pension system's parameters are fixed at the values prevailing before 1997 reform (first column of table 4). The aggregate performance of the model economy in this case is characterized by a progressive reduction in its output growth rate, dropping from an initial 3% value to a figure below 1% in the 2040/2050 decade. This is a consequence of the progressive contraction in the offer of both capital and labor. We can trace the evolution of the relative scarcity of both inputs by monitoring the changes in the capital to labor ratio (first column of table 8). Under the close economy assumption we observe a significant capital deepening, which ends up in 2038 and reverses for the rest of the period.[28] Simultaneously,

[28] This is a result of the interaction between the changes in the age distribution of the population and the different shapes of the age profiles of labor supply and assets holdings.

the social security's financial balance undergoes a striking change, as the size of the pension expenditure almost doubles between 2010 and 2045 (first column of table 9). Under those conditions, the initial surplus of the system cannot be sustained any longer that the mid-twenties (figure 8 and first column of table 10). After 2026 the system runs into deficit, peaking at a 8.7 % of the aggregate product in 2048.[29] In order to cope with this imbalance, the fiscal burden suffered by the agents (measured by the anual average of the lump sum tax-to-gross income ratio, $\overline{\varphi}^t$) should double (first column of table 11).

The differences in life cycle behavior by educational type are illustrated in figure 15 (in the appendix). They can be briefly summarized as follows: low income workers early retire and start receiving the minimum pension immediately, while the rest of the workers wait until the normal retirement age. The change in macroeconomic conditions along the equilibrium path does not alter this behavioral pattern. The Spanish pension system imposes a very substantial redistribution of income along the individual life. This is implemented through very high contribution rates and remarkably generous pensions (the replacement rate over *net* labor income exceeds a 100% in all cases). There are substantial differences in the *level* and *dynamics* of life cycle labor income depending on the educational type. In particular, the concavity of the income profile is much more acute for highly educated workers. Finally, there is considerable variation in the optimal savings and assets accumulation patterns, specially at the beginning of the life cycle (highly educated workers borrow substantially, while the other types start saving from the very beginning). The age of wealth depletion (displayed in the fifth column of table 5) is, however, very similar, as all workers share the same survival process.

5.3 Parametric reforms

We consider four variations to the institutional environment existing before 1997. In first place, we reproduce the basic changes introduced in that year, when the length of the averaging period D was extended form 8 to 15 years and the annual early retirement penalty was slightly reduce from 8 to 7%. We refer to this new parametric scheme as R97 (see table 4). In our view, these changes are not enough to cope with the magnitude of the population aging in Spain, and additional reforms are unavoidable. [30] In this paper we explore two possible ways of *significantly* extending 1997 reform:

- A sharper generosity reduction, implemented through the continuation of the increase in the length of the averaging period in the *regulatory base*. In partic-

[29]Note that, as we do not calibrate the model to reproduce the *size* of pension expenditures and contributions, all our results concerning the *levels* of the pension system are best interpreted as suggestive qualitative predictions.

[30]Some very small additional legislative changes, introduced in 2001 and implemented in 2002, do nothing to remedy this situation (as the OECD report for the Spanish economy OECD (2001) stresses).

ular, we consider a further increase in D from 15 to 30 years. The institutional environment resulting after this parametric change is denoted as R97+.

- A delay in the *normal retirement age*. This implies changing the early retirement penalties in such a way that individuals are awarded their full *regulatory bases* only at the new *normal age*. Following the changes already implemented in USA, we choose 67 as our new legal age. The other parameters of the early retirement penalty are left unchanged.[31] We refer to this new pension system as $\tau_N = 67$.

- Finally, we also consider the simultaneous implementation of the reforms in R97+ and $\tau_N = 67$. This is denoted as the "Double" reform.

5.4 Impact of parametric reforms

5.4.1 1997 Reform

The increase in the number of years included in the *regulatory base* has effects of opposite sign on the pension benefits depending on the individual's labor income dynamics. Highly educated workers, who experience remarkable drops in their earnings at advanced ages, tend to get higher pensions after the reform. In contrast, low income workers, endowed with flatter labor income profiles, tend to suffer reductions in their final benefits. In all cases the size of the changes is moderate. These modifications are not large enough to induce adjustments in the retirement behavior of the agents. On aggregate, the average pension slightly rises, as can be appreciated in figure 9. As this alleviates the need for old age savings, it results in a mild reduction in the aggregate capital stock of the economy (see table 8 for the precise figures). Consequently (tables 11 to 10), the reform generates a small rise in the pension expenditure to output ratio, and a hardly noticeable *upward* shift in the time series of social security deficit and taxes. Figure 8 provides a graphical illustration of the effects on the pension system's financial balance.

We evaluate the welfare impact of the reform by computing its associated compensating variation, CV.[32] Figures 10 to 12 display the results for every cohort and educational type. Most cohorts of high income workers are better off after the reform, as a result of the higher pensions provided. All the other individuals experience small welfare losses, either as a result of lower pensions (average income workers), or as a result of the negative macroeconomic impact of the reform (which reduces the minimum pensions enjoyed by the low income workers).

[31] Keeping α_1 equal to 0.07 implies that α_0 (the replacement rate in the early retirement age) should be reduce to 0.51. In this way, our delay of the normal retirement age also involves a reduction in generosity for early retirees.

[32] The Compensating Variation associated with a reform is defined as the size (in percentage terms) of the parallel shift in the life cycle consumption profile of the agent (in the base simulation) which is needed to keep the initial utility level constant under the economic conditions prevailing after the reform.

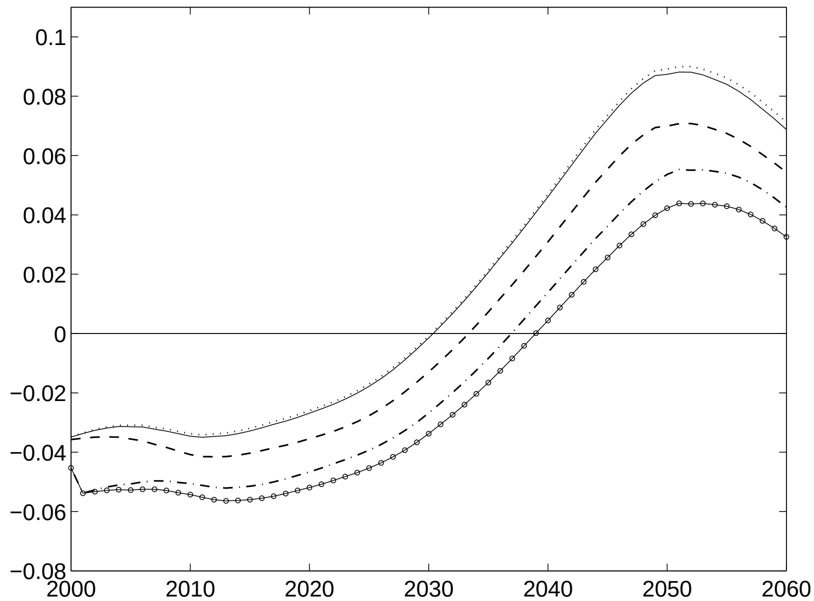

Figure 8: Social Security deficit to output ratio, DSS/Y. Time paths in our sequence of simulations: Base (–), R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double reform (●).

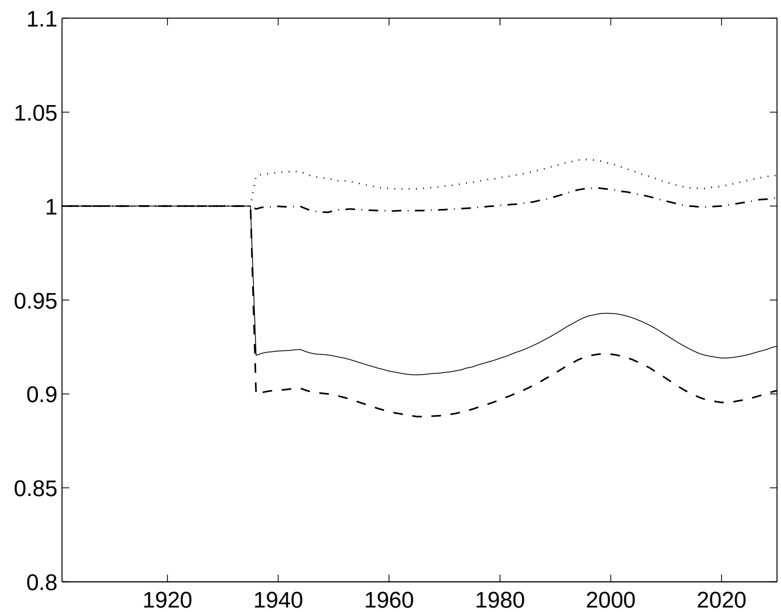

Figure 9: Ratio b^R/b^B of the average pension prevailing after the reforms to the average pension in the base simulation, by cohort. The sequence of reforms is R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–).

5.4.2 A reduction in generosity: the extended 1997 Reform

The most straightforward way to extend 1997 reform is by considering additional increases in the number of years included in the *regulatory base*. In particular, we explore the consequences of averaging the 30 years immediately before retirement. This change leads to generalized drops in individual pensions. The losses are around a 10% reduction for both high a low educated workers, while average educated workers experience more moderate drops. The effect of these drops in the average pension is shown in figure 9. Although quite substantial, these reductions are not enough to alter the retirement patterns of the agents of the model. As a consequence, the full impact of the reform operates through the reduction in the system's generosity.

At the macro level, a sizable process of capital deepening can be appreciated, with gains in the capital to output ratio ranging form 0.5 to 1.7% of the value in the base reform. Increasing the private savings is, therefore, the individual answer to the cuts in public pensions. The financial condition of the pension system is improved: pension expenditure experiences a significant drop (a 5/6% reduction in PP/Y), and this leads to an absolute reduction in the pension system deficit (DSS/Y) ranging from 0.6 to 1.75 percentage points.

Finally, the welfare analysis reveals a substantial amount of both intra- and inter-generational heterogeneity. There are welfare losses for most cohorts of active workers at the time the reform is implemented. This reflects that, for those cohorts, the reform's positive effects (lower taxes and higher labor income) do not compensate for the lower pensions granted under the new formula. This is the case for highly educated individuals born between 1936 and 1988, and for individuals of average education born between 1936 and 1968. In sharp contrast, all cohorts of low educated workers benefit from the reform, as the minimum pension scheme prevents any reduction in their effective pensions.

5.4.3 A two year delay in Normal Retirement Age: $\tau_N = 67$

When the normal retirement age is delayed till 67 the average retirement age increases by more than one year (it goes up to 65.16 from 63.69 in the base simulation). This is the result of both high and average educated workers adopting the new normal retirement age. In contrast, this change has no effect on the retirement patterns of low educated workers, as they continue to leave the labor force as soon as the minimum pension is available. The system's generosity is also altered by this legislative change: those who delay retirement suffer a reduction in their final pensions, as a result of the concavity of the age-profile of earnings. Workers who early retire should experience much more severe reductions in their initial pensions, as the new rules implies an increase in the early retirement penalties. However, minimum pensions can make these workers elude any pension reduction. Overall, both the dependency ratio and the generosity of the system are reduced by the reform.

The impact on the financial condition of the system is important: the drop in pension expenditure range from 10 to 14 %, which allows for reductions in the deficit to output ratio ranging form 1 to 3 absolute points. This latter effect also reflects a moderate capital deepening of the economy, taking place from the third decade of the century onwards. For a majority of the population the associated tax cuts and macroeconomic improvements more than offset the welfare losses derived from the extension in their working careers. Older cohorts at the time the reform is implemented are the exception.[33] Nonetheless, this reforms pareto dominates the pension reduction strategy (R97+): all workers are better off under a delayed normal retirement age than when the averaging period is extended to 30 years (see figures 10 and 11).

5.4.4 The "Double" Reform

We have finally considered the simultaneous implementation of the two basic strategies: to increase the averaging period to cover the 30 years before retirement and to delay the normal retirement age by two years. In general we find that this Double reform is the best option in the long run, but it is also more aggressive with older cohorts than simply setting the new normal age at 67. This is so because the Double reform generates much larger reductions in the initial pensions than those under the τ_N=67 reform (figure 9). It is also the most effective reform in terms of the reductions in the pension expenditure (around 18% reduction in PP/Y) and in the pension system deficit (2 to 4.5 absolute percentage points reduction in DSS/Y). This allows larger tax cuts than in any of the previous reforms. It also generates a substantial capital deepening, although not as strong (in the short run) as that happening under R97+ . These positive effects more than compensate for the negative impact of the lower pensions for middle age agents, but are not enough for active workers of very advanced age at the time the reform is implemented. As usual, low educated workers avoid any welfare losses thanks to the minimum pension scheme.

[33] Cohorts of highly educated workers born between 1936 and 1957 and cohorts of low educated workers born between 1936 and 1941 get worse with the reform.

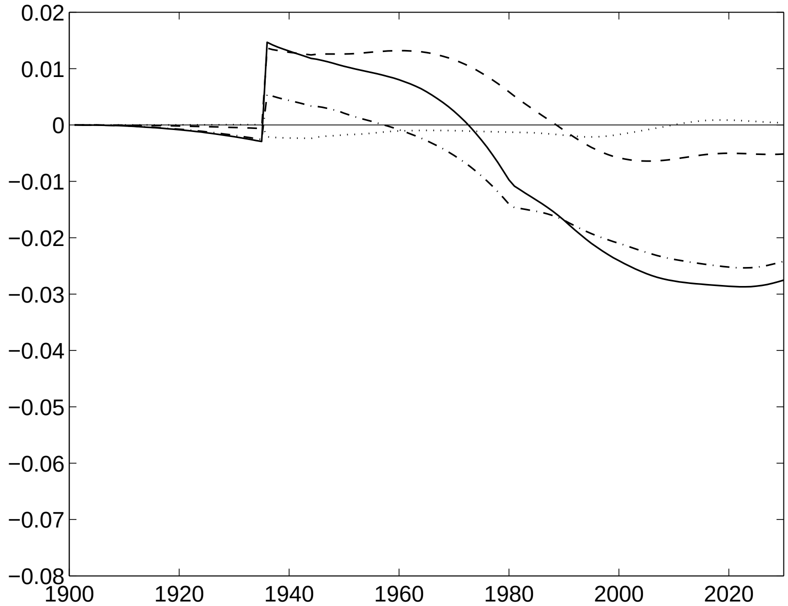

Figure 10: Compensating variation by cohort with respect the Base simulation in our sequence of reforms (R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–)), for Highly educated workers.

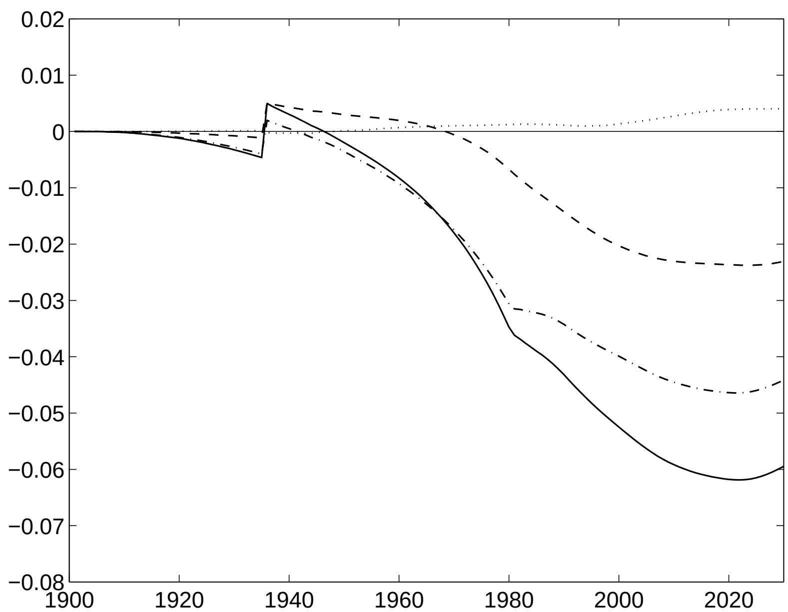

Figure 11: Compensating variation by cohort with respect the Base simulation in our sequence of reforms (R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–)), for average educated workers.

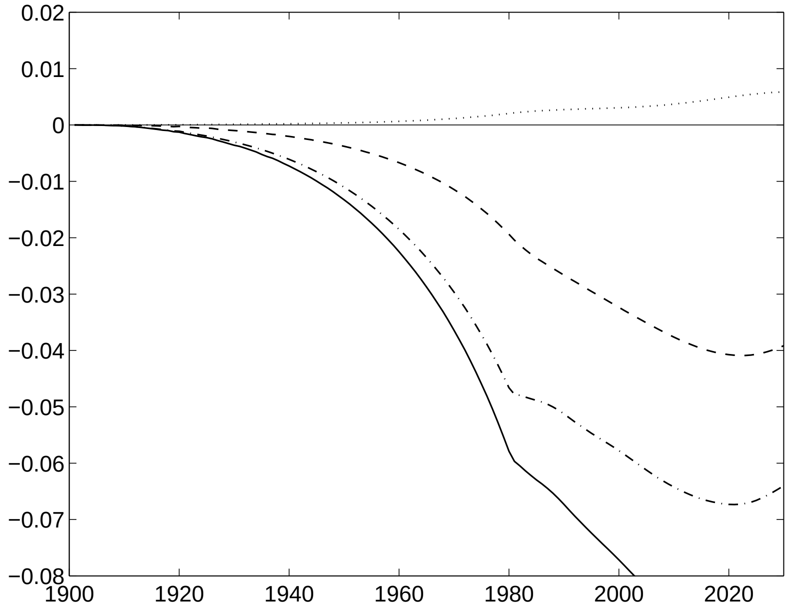

Figure 12: Compensating variation by cohort with respect the Base simulation in our sequence of reforms (R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–)), for low educated workers.

6 Concluding comments

This paper uses a calibrated OLG model to examine the impact of several parametric reforms on the financial sustainability of the Spanish PAYG pension system. Our basic findings can be summarize as follows:

- Legislative changes introduced in 1997 are utterly incapable of helping the system to cope with the effects of future population aging.

- Extending the averaging period in the pension formula to 30 years and delaying the Normal retirement age till 67 are effective measures to reduce the generosity of the system and to keep people working till more advanced ages. As a result, both *additional* changes lead to substantial reductions in the future pension system imbalances. However, they are not enough to make them disappear.

- The implementation of any reform is a matter of substantial inter-generational disagreement: older workers oppose to any of the extended reforms, while younger generations strongly benefit from all of them. Older cohorts would opt to delay retirement age if they were forced to choose some reform, while younger cohorts would prefer the simultaneous implementation of both changes.

  The reforms can also have intra-generational redistribution consequences, which strongly depend on the policy followed with respect to the minimum pensions. If the guaranteed minimum is not subject to benefit reductions, it could protect low income workers from any welfare loss due to the implementation of the reforms.

These *qualitative* findings are likely to be very robust to any further improvement in the modelling process.[34] Nonetheless, we finish the paper commenting on some posible extensions of the model. Firstly, increases in the female participation rates and reductions in unemployment rates could significantly alleviate the condition of the system during the first decades of the century. Extending large scale OLG models to include these two features will improve the quality of their predictions about the pension system's levels, although that improvement is a major challenge to our current modelling and computing capabilities. Secondly, getting a more detailed reproduction of the institutional environment is a less ambitious but also quite relevant improvement. In particular, the consideration of survival pensions (typically in conjunction with gender heterogeneity), the inclusion of the Self-employed Regime and the enrichment of the current representation of the General Regime, will help us to improve the calibration of the *levels* of the system and the reproduction of empirical the retirement patterns. Finally it is important to account for the differences between natives and immigrants in dimensions like income processes and fertility. As the size of this collective is going to experience a substantial increase in the future, these differences are due to play a significant role in the future evolution of the pension system's financial condition.

[34] We have actually checked the robustness of the qualitative findings against changes in the fiscal system, the public expenditure policy, and the "close" economy assumption.

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A The solution of the individual problem

The solution technique for the individual problem stated in section 3.2.3 follows the results in Crawford and Lilien (1981), Fabel (1994) and Leung (2000). The basic idea is to transform the original deflated problem by introducing a new decision variable: the age when the credit constraint becomes binding $\bar{t}$. The procedure to solve the new problem is as follows. Firstly, for every couple $(\tau, \bar{t})$ we obtain the optimal conditional life-cycle consumption $\{c_i(\tau, \bar{t})\}$. This is not computationally intensive, as the individual problem can be solved with the help of lagrangian methods. In a second stage, we compute the optimal *binding age* for every possible retirement age, $\bar{t}(\tau)$, which is characterized by the condition:

$$c_{\bar{t}(\tau)}(\tau, \bar{t}(\tau)) = ib_{\bar{t}(\tau)}(\tau)$$

Finally, the optimal retirement age is obtain by maximizing:

$$V(\tau^u) = \sum_{i=1}^{I} \beta^{i-1} \, s_i^u \; u[\, c_i(\tau^u, \bar{t}(\tau^u)) \, , \, l_i \,]$$

This process must be done for every cohort and educational type. An example of the application of this method can be found in Jiménez-Martín and Sánchez-Martín (2003).

B Age profiles of labor income and hours worked.

As we abstract from unemployment or non participation, the age profiles of labor income and hours worked by educational type implemented in the model correspond to the average profiles in the entire working-age population. The procedure is as follows. We first estimate the participation rates and the profiles of hours worked by employees, according to age and education. By multiplying both profiles together, we get the empirical profiles of hours worked by age for each of our educational types. A smoothed (quadratic) version of those profiles, fitted by OLS, is finally included in the model. The productivity profiles have been recovered in a similar way. We first estimate the age profile of labor income for employed workers by education. We then compute the empirical profiles for our representative agents by weighting them with the employment rates. Again, the profiles included in the model are a smoothed (quadratic) version of the logarithm of the empirical one, fitted by OLS.

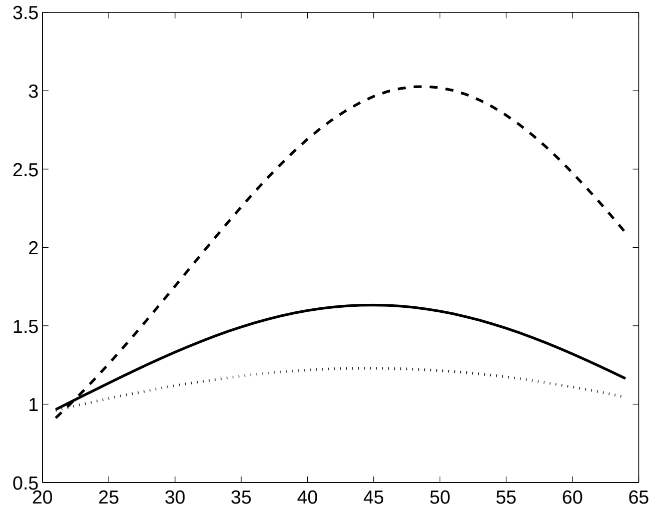

Figure 13: Life-cycle gross labor income profiles by educational type: High (- -), average (-) and low (·) educated workers. Source: ECHP94

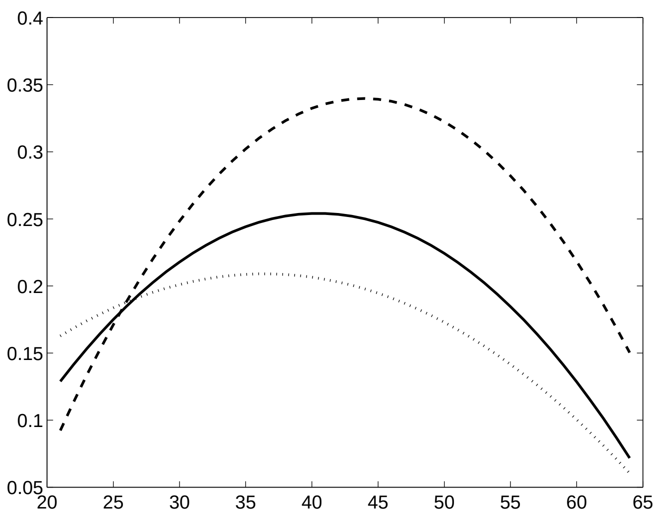

Figure 14: Life-cycle profile of hours worked by educational type: High (- -), average (-) and low (·) educated workers. Source: ECHP94

C Simulations Results

Table 8: Capital to labor ratio, $\mathbf{K/H}$, in our sequence of simulations.

	Base	R97	R97+	$\tau_N = 67$	Double
2000	4.14	4.14	4.14	4.09	4.09
2010	4.28	4.28	4.30	4.28	4.29
2020	4.51	4.50	4.55	4.51	4.54
2030	4.72	4.71	4.77	4.72	4.75
2040	4.75	4.75	4.81	4.76	4.80
2050	4.55	4.55	4.62	4.60	4.65
2060	4.28	4.27	4.35	4.34	4.39

Table 9: Aggregate pension expenditure to output ratio, $\mathbf{PP/Y}$, (in percentage form) in our sequence of simulations.

	Base	R97	R97+	$\tau_N = 67$	Double
2000	15.00	15.01	14.92	13.96	13.96
2010	15.02	15.10	14.40	13.43	13.05
2020	15.79	15.88	14.93	13.81	13.29
2030	18.33	18.40	17.18	15.80	15.10
2040	23.09	23.18	21.57	19.86	18.92
2050	27.22	27.39	25.47	23.84	22.70
2060	25.36	25.61	23.92	22.74	21.75

Table 10: Social security deficit to output ratio, **DSS/Y**, (in percentage form) in our sequence of simulations.

	Base	R97	R97+	$\tau_N = 67$	Double
2000	-3.49	-3.48	-3.57	-4.53	-4.53
2010	-3.46	-3.38	-4.08	-5.05	-5.43
2020	-2.68	-2.60	-3.55	-4.66	-5.19
2030	-0.15	-0.08	-1.29	-2.68	-3.38
2040	4.61	4.70	3.09	1.39	0.44
2050	8.74	8.91	6.99	5.36	4.23
2060	6.88	7.13	5.44	4.26	3.26

Table 11: Average individual **tax burden**, $\overline{\varphi}$, (in percentage form) in our sequence of simulations.

	Base	R97	R97+	$\tau_N = 67$	Double
2000	13.89	13.91	13.75	11.43	11.40
2010	19.65	19.84	18.19	16.23	15.29
2020	21.27	21.49	19.24	17.09	15.77
2030	25.66	25.83	23.02	20.60	18.88
2040	33.26	33.46	30.02	27.52	25.38
2050	39.74	40.10	36.20	34.22	31.81
2060	35.89	36.42	32.95	31.46	29.32

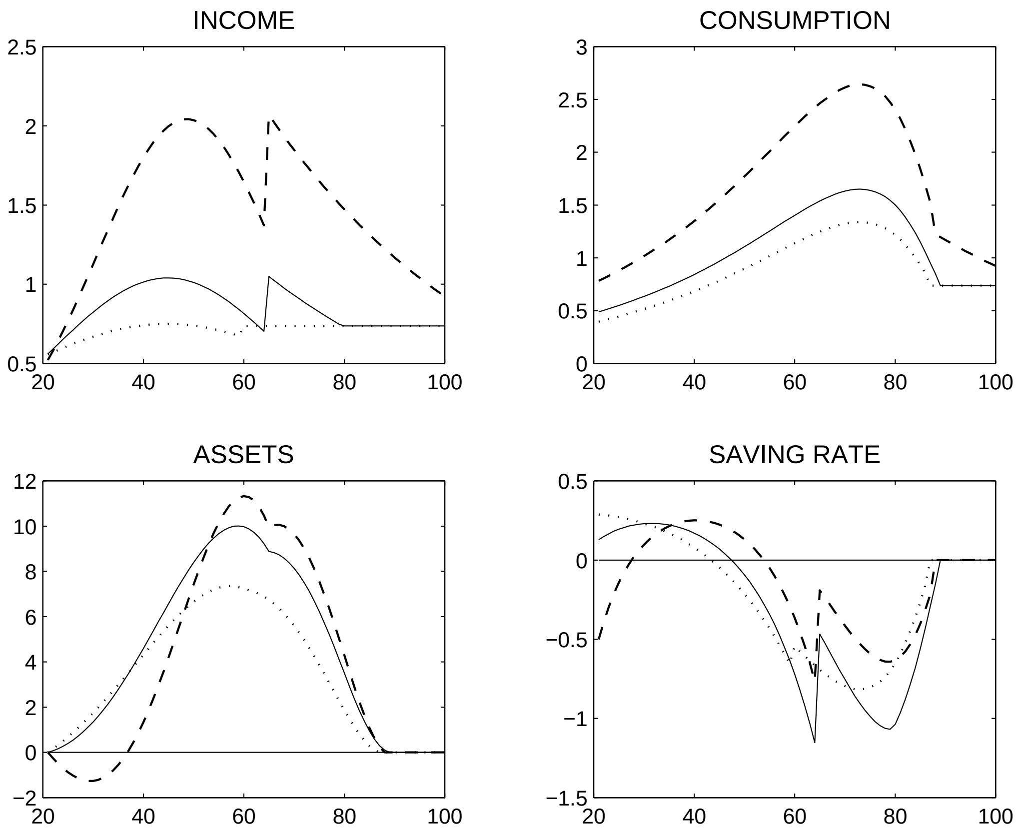

Figure 15: Base Simulation: life cycle behavior for the cohort born in 1970 by educational type: low (·), average (-) and high (- -). All variables are deflated of productivity growth).