Endogenous Retirement and Public Pension System Reform in Spain *†

Alfonso R. Sánchez Martín
Imperial College London

February, 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 particular, pension formulae have been modified to reduce the generosity of the systems and to induce longer working careers. 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 an Heterogeneous Agents, Applied General Equilibrium model where individuals can freely adjust their retirement ages in response to the incentives provided by the pension regulations. This inclusion is relevant, as *parametric* changes tend to significantly alter retirement incentives. 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 far away from being able to fully restoring it.

JEL CLASS.: D58, H55, J1, J26

KEYWORDS: Applied General Equilibrium, Retirement, Social Security Reform

---

* This paper is an extension of one my dissertation's chapter. The thesis was written at Universidad Carlos III de Madrid, while the extension has been supported by 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 author is solely responsible for the opinions presented in this paper. They do not represent the opinion of the E. Community. I am grateful to Javier Díaz Giménez, María J Luengo, Sergi Jiménez and Juan Rojas for useful comments and suggestions. I also thank seminar participants at MadMac (CEMFI), Universidad Carlos III's macroeconomic workshop, FEDEA, XXVI Simposio de Análisis Económico (Alicante) and "2002 Conference on microeconometric models and simulation tools for fiscal policy" at Instituto de Estudios Fiscales (Madrid). Of course, all remaining errors are mine.

† The Business School. Imperial College London, 53 Prince's Gate, Exhibition Road, London SW7 2PG. Tel +44 (0)20 759 49115 Email: alfonso.martin@ic.ac.uk

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 funded mechanisms. However, most industrialized countries have not go any further than introducing mild *parametric* changes to the existing public systems.[1] The majority of those reforms have aimed to reduce the generosity of current systems, to increase the linkage between contributions and pension benefits and to encourage the labor participation of older workers.

The project In this paper we explore the ability of this type of reforms to enhance the financial perspectives of PAYG public pensions systems in the next fifty years. This is undertaken via simulation in an Heterogeneous Agents, Large Scale, OLG model, calibrated to reproduce: (1) Spanish demographic process, (2) the institutional details of the Spanish Old Aged Pension System, (3) average retirement age and (4) the basic macroeconomic aggregates of the Spanish economy.

Previous answers The capacity of parametric reforms to help to cope with the burden of demographic changes has been the subject of several previous works. A first example 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. This analysis is implemented in a deterministic large scale OLG model (in the Auerbach and Kotlikoff (1987) tradition), calibrated to generate quantitative predictions for 4 developed economies. Both changes results in 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 the ones reported in De Nardi, İmrohoroğlu, and Sargent (1999), in a model including a remarkably improved treatment of the uncertainty at the individual level. They explore the consequences of linking the benefits to the record of individual contributions, of making the pension benefits subject to taxation and of progressively delaying the *mandatory* retirement age.

There are some aspects of this previous literature that are not very satisfactory. In first place, real world governments cannot directly determine the workers' retirement age. In general, they can only have an indirect impact on the individual behavior by changing the *incentives* implicit in the pension rules. So whether parametric reforms can actually delay retirement ages is a question that still remains opened. Secondly, reductions in pension generosity can increase the marginal cost of working at advanced ages, and so 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 parametric changes on the Social Security accounts. This aspect has not been taken into account in

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

the previous literature, which (by assuming a mandatory retirement age) has abstracted completely of the existence of Early Retirement.[2]

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

(i) Increases in the number of working years included in the pension formula, intended to reduce the generosity of the system.

(ii) A delay in *Normal* retirement age from 65 to 67.

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 a further extension of this number to 30, according to a recent and highly controversial governmental proposal in Spain. In contrast, (ii) is inspired by the changes introduced in 2000 by US Social Security Administration, and has not been explicitly included in the Spanish political agenda so far. It is, however, very likely that this change will be under consideration in the near future, not only in Spain but in most European economies facing similar demographic crisis.

In order to properly handle the effects of these changes we design a model economy with the following features: individuals decide when to retire, private markets are incomplete (borrowing from future pension income is forbidden and there is no annuity market to insurance from life uncertainty), individuals within a cohort are heterogeneous in their educational achievements (which implies intra-cohort differences in life cycle earnings and hours worked), a very detailed public pension system is reproduced (including the benefit formula, the early retirement penalties and the minimum pension rules governing old age pensions under the main social security program in Spain), and flows of workers from abroad are allowed. Relative to previous work our main contributions are the endogenous treatment of retirement and the implementation of the borrowing constraint at the end of the life cycle.[3]

Findings We first show that our calibrated general equilibrium model is capable of reproducing the basic stylized facts of retirement in Spain. Minimum pensions and the inclusion of labor income heterogeneity are the critical elements leading to this achievement. We then explore the impact of the several reforms considered, with the following results:

[2]This abstraction could be legitimate if the pension benefits were adjusted with retirement age in an actuarially fair way. But this is not the case in the Spanish pension system.

[3]Our model can be considered at the forefront of the literature using Auerbach and Kotlikoff (1987) methodology to assess the non-stationary, short run effects of aging. Previous examples are Auerbach, Kotlikoff, Hagemann, and G. Nicoletti (1989), Chauveau and Loufir (1997), De Nardi, İmrohoroğlu, and Sargent (1999), Kenc and Perraudin (1997b) or Miles (1999), while the Spanish case has been studied in Conesa and Garriga (1999), Rojas (2000), or (abstracting from Social Security) Rios-Rull (1994). Only the papers reviewed in the main body of this text address the question of parametric reforms. In contrast, there is a large literature on the privatization of the system. Our treatment of the borrowing constraint at the end of the life cycle follows Crawford and Lilien (1981), Fabel (1994) and Leung (2000).

- If kept in its current form, the public pensions system would run into deficit from 2025 onwards. The imbalance will peak around 2045, at a figure close to a 9% of GNP.[4] 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 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 strong impact of minimum pensions on the intra-generational distribution effects of the reforms.

Sectioning The rest of the paper is organized as follows. In section 2 we review the basic stylized facts of labour supply at advanced ages in Spain, and discuss their interactions with the public pension rules. This analysis provide the motivation for the ingredients of our model economy, with special emphasis in the need for an endogenous retirement decision. 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 some tables and graphs are confined to a final appendix. The paper finish with some concluding comments in section 6.

2 Pension rules and the labour supply of older workers

In this section we review the basic labour supply patterns of older workers, and discuss their economic interpretation. We focus on the interaction between pension rules and retirement behaviour. This analysis provide the rationale for our modeling choices. 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.[5]

[4] As the model abstracts from potentially important elements (as changes in unemployment or female participation patterns), results concerning the *levels* of pension expenditure and deficit should not be literally interpreted as quantitative predictions for the *real* Spanish economy. Instead, they should be interpreted as suggestive qualitative patterns.

[5] 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 had in common the effort to reduce the dispersion

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 labour 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 a pension. A complete withdrawal from the labour force is also a requirement to start collecting the benefit. The initial amount is obtained 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 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. [6] 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 in the *regulatory base* is applied 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 RPI.

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 constant in real terms during the same time interval.

2.2 Labour supply patterns of older workers

The labour supply of Spanish older workers is characterize by the following empirical regularities:

R1 Sharp discontinuities in retirement hazard in both the *early* retirement age (60) and the *normal* retirement age (65).

R2 Most (67.7% in 1995) early retirees are low income workers who are subject to the minimum pension scheme.

R3 "Working hours" do not react to changes in effective contribution rates along the individual life cycle.

in regulation, making the General Regime the cornerstone of the entire system. As a result, 73.9% of the affiliated workers belongs to the RGSS in 2001, although 45% of the existing pensions in the same year were been awarded under different regimes. That is one the reasons why the inclusion of other regimes is an important future research line.

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

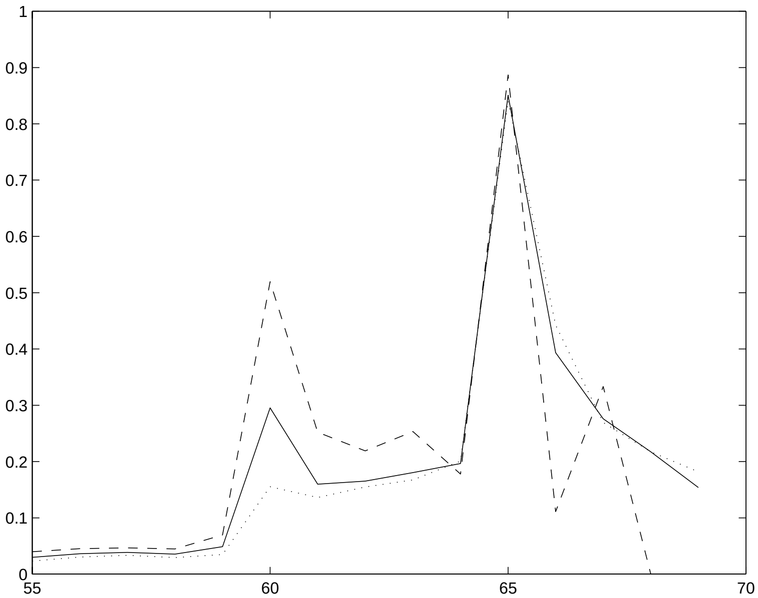

Figure 1: Retirement hazard by age: total population (-), perceptors of minimum pensions (- -) and non-perceptors (·). Source: HLSS, 1995

Most workers withdraw from the labour 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.[7] The composition of the hazard peaks according to the level of the individual's labour income is analyzed in figure 2. This is done by constructing a non-parametric estimation of the retirement hazard at every age as a function of the level of labour income at the age of 60. We find that, while the probability of leaving the labour force is not affect by the salary level at the *normal* retirement age, there is a clear decreasing pattern at the *early* retirement age. This pattern is basically independent of the individuals' educational achievement.[8]. 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 check this directly in the 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). Finally, figure 3 shows that the average profile of hours worked for a full time worker in Spain is remarkably smooth.

[7]Our data come from a sample of administrative records from the Spanish Social Security in 1995, but virtually identical patterns can be found in other available data bases (eg. the European Household Panel (ECHP), the Family Income Survey (EPF) or the Labour Force Participation Survey (EPA)). Across countries 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).

[8]The educational level is not observable in our sample of social security records, but can be approximated by the social security contribution group

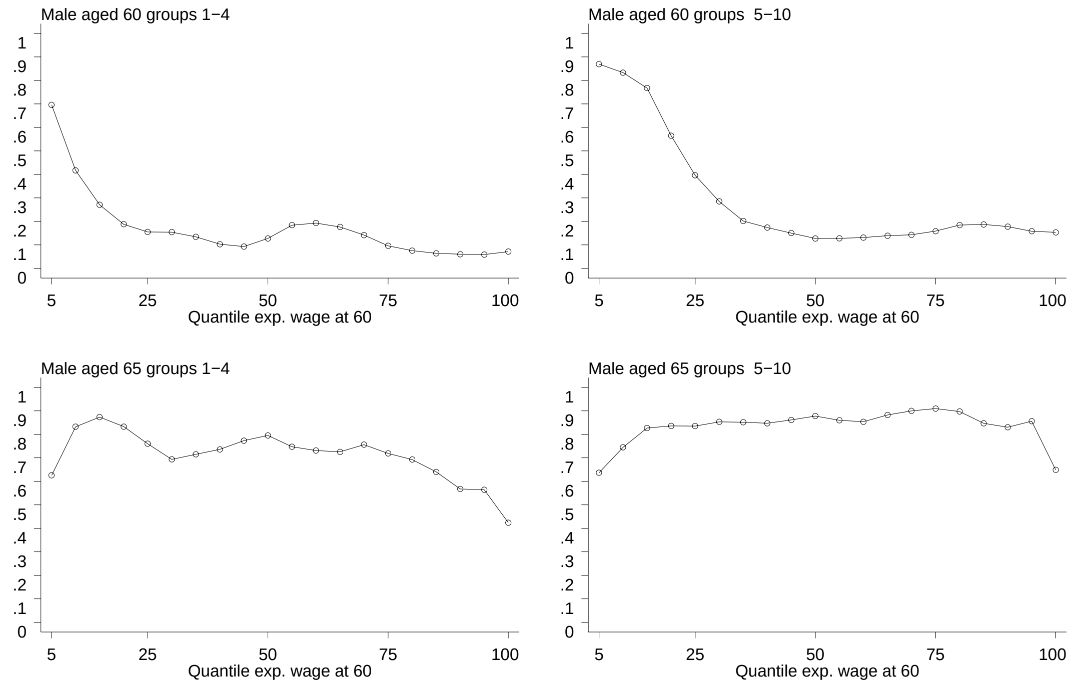

Figure 2: Retirement hazard at the ages of 60 (top panels) and 65 (bottom panels) for high (left panels) and low (right panels) educated workers, by wage level at the age of 60. Source: HLSS, 1995

2.3 The causal effect of pension rules on labour supply patterns

In this section we discuss whether the stylized facts R1 to R3 can be rationalized as the optimal reply of rational individuals to the incentives provided by the pension regulations. All discussion will be kept at an informal level. A formal treatment of the topic can be found in chapters 1 & 2 of Sánchez-Martín (2002).

Pension rules and retirement behaviour

The easiest way to understand the impact of pension rules in retirement behavior is by showing the distortions they create on the marginal benefits and costs of working. At any age τ, there are two marginal costs for keeping employed: the reduction in leisure time and the foregone pension benefit (only if the worker is older than the early retirement age). On the other hand, keeping working allows the individual to collect a salary and to change the pension benefit he is entitled to in the future. This latter change 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 labour income moves into the averaging period and substitutes for the value observed 15 years before. Note that while the first effect always results in a higher benefit, the second can have the opposite effect. This is a direct consequence of the concavity of the life cycle profiles of gross labour income (see figure 15 in the appendix).

Keeping all that in mind is not difficult to explain the age 65 peak in retirement hazard (R1). 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 typically reaches its maximum at that age. This conclusion is supported by the results of a number of different studies.[9] It is also quite easy to rationalize the early retirement patterns as an artifact of the minimum pension mechanism. As the value of the minimum is completely independent of the individual circumstances, it eliminates all the incentives stemming from the pension formula. In particular, it wipes out the strong incentives to work associated with the early retirement penalties. It also increases the opportunity cost of the foregone pension. Therefore, the optimal behaviour under this mechanism is to leave the labour force as soon as the pension is available, ie at the early retirement age.

In general, we conclude that there is enough support to the view that the empirical regularities R1 & R2 can be explained as the logical consequences of quite simple economic interactions. More concretely, that they can be interpreted as the optimal reply to the non-linearities induced by the pension rules on the individuals' intertemporal budget constraints.

Pension rules and hours worked

While participation appears in the data as a process highly sensitive to the incentive provided by the pension rules, there is much smaller evidence of this influence on the decisions on the intensive margin, ie, the "hours" worked. A good example of this unresponsiveness can be found when analyzing the response of hours worked to the life-cycle changes in *effective* contribution rates.[10] 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 in Spain, as the figures in table 1 make apparent for an employee whose life cycle profile of income coincides with the median of the empirical distribution (in ECHP94). Regardless of the retirement age, the *effective* rates are substantially negative in the ages included in the *regulatory base*. This should represent a strong incentive to increase labour supply in the years immediately before

[9] 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 behaviour in presence of these incentives is calculated in chapters 1 and 2 of Sánchez-Martín (2002) for the Spanish case. The simulations confirm that waiting till τ_N is optimal for most workers, with the exception of those in both tails of the labour income distribution. Finally, several structural econometric estimations have confirmed the contribution of these factors to generate the retirement behaviour actually observed in the data. Jiménez-Martín and Sánchez-Martín (2000) is a reference for the Spanish case, while Rust and Phelan (1997) shows that including the details of the Health Insurance System is very important to capture the magnitude of the peaks in USA.

[10] 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.

retirement. However, there is no trace of such behaviour in the Spanish data (figure 3). This could be a consequence of institutional constraints that prevents workers from implementing their optimal life cycle labour supply profiles. 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 be blame for this rigidity in the Spanish labour market.

2.4 Modeling strategy

The generosity of the Spanish public pension system fluctuates with retirement age. In particular, early retirees are substantially more expensive than normal retirees in Spain, as a result of the generosity of the minimum pension scheme.[11] If this is combined with (1) the fact that the reforms analyzed in this paper are going to alter the age profile of retirement incentives (some are actually going to be design with that specific purpose), and with (2) the empirical evidence showing a high sensitivity of individual behaviour to those incentives, we can only conclude that an endogenous retirement age is a need to give a sensible answer to the question in this paper. To reproduce the empirical patterns R1 & R2 we also need a heterogeneous agent model (with workers differing in their labour income process) including the minimum pension mechanism. On the other hand, there is no doubt that the reforms we study in this paper are going to modify the incentives on the intensive margin of labour supply. There is no reason, however, why we can assume that the institutional constrains that have blocked the transmission of those incentives to actual behaviour in the past are going to be weaken in the future. Keeping this in mind, the simplest and more coherent modeling strategy for the hours worked is to plug into the model the empirical life cycle profiles, and to keep them exogenously fixed all along the simulations.[12]

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.

[11]This can be assess by comparing the internal rates of return obtained by the contributions paid during the working years. See chapter 2 in Sánchez-Martín (2002).

[12]Ideally, it would be better to work with an endogenous hour decision in a model including all the relevant institutional constraints. This task, however, goes clearly beyond our goals in this paper. It is also interesting to note that the previous literature has modeled an endogenous hours decision under the assumption that individuals were ignorant of the legislation.

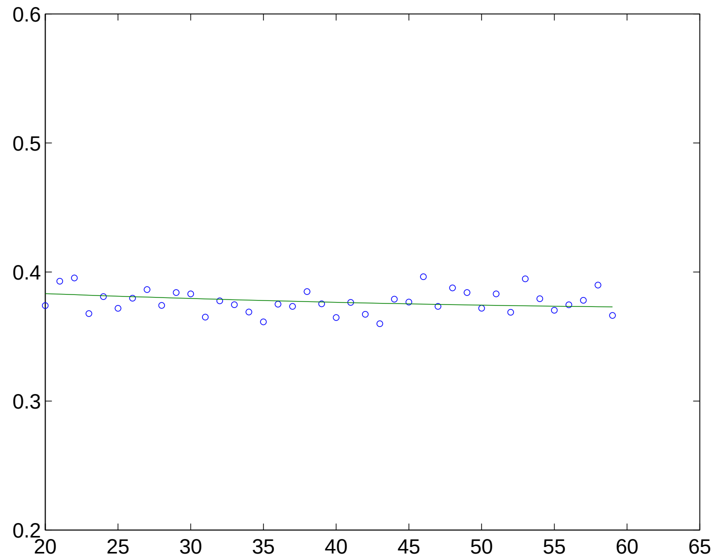

Figure 3: Life Cycle profile of hours worked (as a fraction of the individual time endowment, normalized to unity) for full time workers in ECHP, 1994.

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

Table 1: Effective contribution rates for an Spanish representative worker retiring at τ= 55, 60 and 65.

INDIVIDUALS			
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	$V_j(\tau,u)$		
AGGREGATES			
Public Policy		**Macroeconomic**	
Revenues form bequests	IH^t	Product	Y^t
Fiscal Revenue	IF^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/Immigrants	N^t, M^t	Rental capital price	r^t
Age distribution	$\mu^t_{i,j}$		

Table 2: Model notation: endogenous variables. 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: Parameters defining individual preferences and the economic and demographic environment.

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 θ_i^t $(f_0 \leq i \leq f_1)$:

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

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.

Mortality dynamics is captured by the vector of age-conditional survival probabilities hs_i^u. Rewriting in current-calendar-time terms and denoting the net immigrants flows by F_i^t, we find that after birth population dynamics for both natives and migrants is given by:

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

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 $\overline{F}^t = \{F_i^t\}$:

$$\overline{P}^{\,t+1} = \Gamma^t \, \overline{P}^{\,t} + \overline{F}^t \qquad t \in \{t^0, \ldots, t^2\} \tag{3}$$

The simulation starts at t^0 with the beginning of demographic change (figure 4). The behavior of the system in the short run is governed by a changing Γ^t, which is going to reflect calibrated patterns of fertility recovery and life expectancy continuous gains. In the long run we simply assume that both fertility and mortality stabilize after t^1 and that flows form outside eventually die out after that date. As a result, population behaves in the long run according to

$$\overline{P}^{\,t+1} = \Gamma \, \overline{P}^{\,t} \qquad t \geq t^2 \tag{4}$$

Note that the effects of demographic transition remains until t^2. After that date both the population and the economy converge to a steady state which -we assume- is reached at t^3.

3.2 Economic Model

It is a highly stylized representation of a closed economy.[13] There are two goods in the model: time (an individual endowment that can be enjoyed as leisure or hired to the firms in the labour market) and a consumption good (that can be saved and lent through the credit market under some restrictions). At the aggregate level the economy is deterministic while at the micro level individuals are uncertain about the length of their life. Private annuity markets are closed by assumption and the public sector entirely confiscate the savings (or debts) left by people who die early. This implies that output is obtained every

[13]There are no trade or capital flows, although the entrance of workers from abroad is permitted.

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

period by combining the stock of capital saved by the individuals who survive form the previous period and current workers' labour supply.

3.2.1 The Public Sector (SP)

The main role play 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 labour earnings. Following a complete withdrawal from the labour force, workers can claim the pension benefit after the *early retirement age* τ_m. The *initial* pension for an individual belonging to cohort u and retired at age τ is computed as follows:[14]

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

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

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

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 τ is given by:

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

[14]Floor and ceilings on covered earnings and maximum pensions are omitted in this simulation. This is done in an attempt to obtain a sharper characterization of the effects of the included regulations (pension formula and minimum pensions).

The public Sector also runs a non-distorsionary fiscal system an incurs some public expenditure CP^t. Annual fiscal revenue is obtained from the full confiscation of (involuntary) bequests and from a system of lump sum taxes φ^t.[15] All revenue is applied to finance public consumption (which does not increase personal utility) and any potential Social Security deficit. This balance is achieve by fixing φ^t every period in such a way that the 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 technology index A^t). We also assume a constant growth rate ρ for productivity. Finally, we assume this technology to be run by profit maximizing competitive firms.

3.2.3 The Households

Each individual has an endowment of one unit of time per period. The productive capacity of that time 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. As we abstract from schooling and labour market entrance decisions, we impose an exogenous distribution of educational types that remains unchanged both throughout the life of the cohort and between cohorts. The fraction of time allocated to market activities is also exogenously fixed by the reasons discussed in section 2.4.

Agents in the model take two types of decisions: the intertemporal allocation of consumption and a "once and for all" retirement decision, in an effort to maximize expected lifetime utility.[16]. The formal statement of the individual problem (omitting the educational type to simplify the notation) is as follows:

$$
\begin{array}{cl}
\underset{\tau^u,\ \{c_i^{u+i-1}\ a_i^{u+i-1}\}_{i=1}^I}{Max} & \sum_{i=1}^I \beta^{i-1}\, s_i^u\ u(c_i^{u+i-1}, l_i) \\
 & \\
 & c_i^{u+i-1} +\ a_{i+1}^{u+i} = (1-\varsigma)\, il_i^{u+i-1} + (1+r^{u+i-1})\, a_i^{u+i-1} - \varphi^{u+i-1} \\
 & c_i^{u+i-1} + a_{i+1}^{u+i} = ib_i^{u+i-1}(\tau) + (1+r^{u+i-1})\, a_i^{u+i-1} - \varphi^{u+i-1} \\
 & a_1^u = 0 \qquad a_I^{u+I-1} = 0 \qquad a_i^{u+i-1} \geq 0 \qquad \forall\, i \geq \tau
\end{array}
\tag{8}
$$

where the first constraint is relevant in the years before retirement, $i \in \{1, \ldots, \tau-1\}$ while the second operates after leaving the labour force $i \in \{\tau, \ldots, I\}$. Gross labour income at age i and calendar time t is $il_i^t = w^t\, \varepsilon_i^t\, (1-l_i)$ and pension income at age i in t

[15] We also simulate the model under a proportional income tax scheme, without any significant change in the qualitative results. The non-distorsionary system is, however, far easier to interpret. This is a consequence of using the tax rate to balance the public budget: whenever the financial condition of the pension system is altered, the tax rate is modified, and this creates additional distortions on individual behaviour in a distorsionary tax system.

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

is given in (5) and (7). Constraints in the last row of the problem state the assets' initial and final conditions and the prohibition to borrow from future pension income. [17]

3.2.4 The Equilibrium.

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

1. Population aggregates $\{N^t, M^t, P^t, F^t\}$ and population distributions by age and education $\mu^t_{i\,j}$
2. 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 $j \in \mathcal{J}$. [18]
3. Inputs employed by the competitive firms $(K^t, L^t) \quad t \in \mathcal{T}$
4. A Public Policy $\{\varphi^t, bm^t, CP^t\} \quad t \in \mathcal{T}$.
5. A price system: $\{r^t, w^t\} \quad t \in \mathcal{T}$

such that the following properties apply:

1. Endogenous population dynamics

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

   The individual assignments solve the individual problem (8) given the price system and the public policy.
3. Competitive prices.

   $$r + \delta = F_K(K^t, L^t) \qquad w^t(1+\varsigma) = F_H(K^t, L^t)$$
4. Factor markets clearance.

   Capital and labour effectively employed by the firms result form the aggregation of individual savings and labour supply:

   $$L^t = A^t\, H^t \qquad H^t = \sum_{j=1}^{J} \sum_{i=1}^{\tau_j - 1} P^t_{i\,j}\ \varepsilon_{i\,j}\ (1 - l_i) \qquad K^t = \sum_{j=1}^{J} \sum_{i=1}^{I-1} P^t_{i\,j}\ a^t_{i\,j} \quad t \in \mathcal{T} \tag{9}$$

[17] The solution technique 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 constraints become binding $\bar{t}$. The new problem is solved in three stages. First, we compute the analytical expressions of the optimal *assignments* for every couple $(\tau, \bar{t})$. These expresions are used in a second stage to obtain the optimal *binding ages* for every possible retirement age, $\bar{t}(\tau)$ (with its associated optimal life cycle consumption profile $\{c_i^{u+i-1}(\tau, \bar{t}(\tau)\} \quad i \in \{1, \ldots, I\}$. Finally, the optimal retirement age is obtain by maximizing:

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

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

5. Public Budget Balance.

$$IF^t(\varphi^t) = DSS^t + CP^t \qquad t \in \mathcal{T}$$

where fiscal revenues IF^t and taxes from bequest take the form:

$$IF^t(\varphi^t) = \varphi^t P^t + IH^t \qquad IH^t = \sum_{j=1}^{J}\sum_{i=1}^{I-1}(1 - hs_{i,j}^{t-i})\, P_{i\,j}^{t-1}\; a_{i+1\,j}^{t-1} \tag{10}$$

Social Security deficit is given by

$$DSS^t = PP^t - \varsigma w^t H^t \qquad PP^t = \sum_{j=1}^{J}\sum_{i=\tau_j}^{I} P_{i\,j}^t\; ib_{i\,j}^t(\tau_j) \quad t \in \mathcal{T} \tag{11}$$

where PP^t stands for aggregate pension expenditures.

6. Aggregate feasibility

$$Y^t + (1-\delta)\,K^t + IH^t = K^{t+1} + IH^{t+1} + \sum_{j=1}^{J}\sum_{i=1}^{I} P_{i\,j}^t\, c_{i\,j}^t + CP^t \quad t \in \mathcal{T} \tag{12}$$

Following Auerbach and Kotlikoff (87) the "Equilibrium" includes three particular forms of the previously defined object: (1) a path along the time interval $\mathcal{T} = \{t^0, \ldots, t^3\}$ (see figure 4) converging to a (2) Final Steady-state, and (3) an Initial Steady State from where initial conditions at the time the simulation starts are taken.[19] The Steady States are particular cases of the Equilibrium path defined above, were the population is stable an growth at a constant rate; aggregate variables grow at a fixed rate given by the sum of the growth rates of the productivity and the population; *per capita* variables and wages grow at the productivity growth rate and the interest rate is constant.

[19]Initial conditions depends on the cohort:

- Very old individuals at t_0 are already retired when the simulation starts. Their initial conditions include their (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.
- 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.

4 Calibration

We calibrate the previous section model according with the following objectives: **(i)** set up an immigration and demographic scenery consistent with the historical Spanish patterns; and reproduce **(ii)** the basic regulations of the Spanish pension system, **(iii)** the key ratios of the Spanish income and product accounts, **(iv)** the average retirement age and the basic qualitative features of retirement behaviour 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. **(iv)** is a consequence of the importance of retirement behaviour for the financial balance of the pension system. A key determinant of retirement decisions is the interaction between pension rules and individual labour income processes. That is the rationale for our final target **(v)**.

4.1 Immigration and Demographics

A period in the model stands for a year of calendar time. We assume that individuals start their life in the model when they are 20 years old and that the maximum possible length of life is 100 (ie , I=80). Demographic patterns are non stationary between $t_0 = 1995$ and $t_1 = 2050$. They are characterized as follows:

- **Fertility** We model the recovery of fertility through parallel shifts of the age specific fertility rates θ_i. The pace of these shifts is controlled in such a way that the implied values of the total fertility rate are 1.7 and 1.75 in 2025 and 2050 respectively.[20] This process is illustrated in the upper panels of figure 5.

- **Mortality** We make every cohort enjoy a higher conditional survival probability hs_i. This increase is parametrized in such a way that the life expectancy goes up linearly from the value observed in 1995 (77.2 years) to 80.4 in 2050. Again, figure 5 shows the process of mortality reduction.

- **Immigration** We reproduce the initial stock and the age distribution of foreigners living in Spain at the time the simulation starts.[21] 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 will triple over our 50 years simulation horizon. Unfortunately, the calibration of immigrants cannot go any further than this. The absence of reliable empirical data prevents us from reproducing in the model the differences in earnings or demographic patterns.[22]

[20] This projection reproduces INE (1995) intermediate scenery, and is a good example of the figures usually found in the literature.

[21] 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 through the INE web site.

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

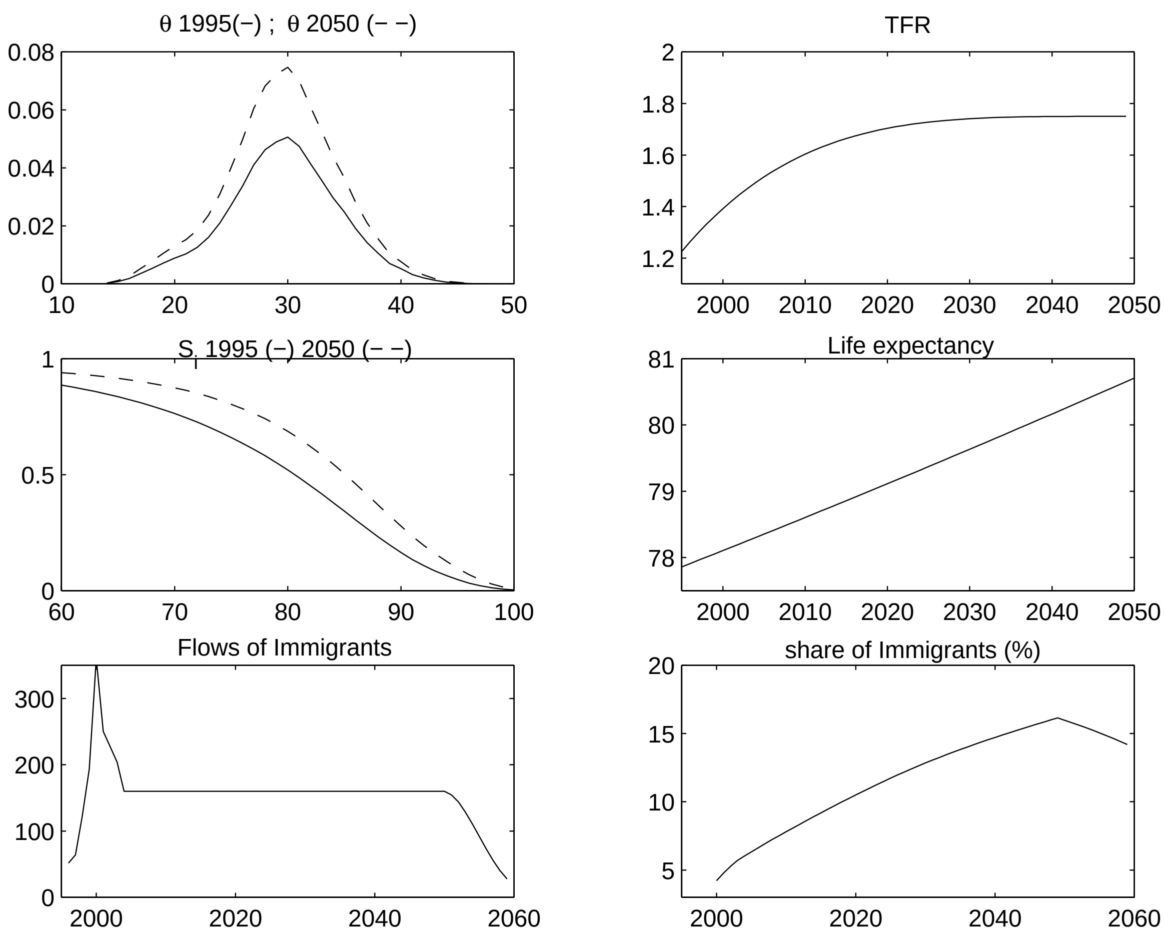

Figure 5: **Fertility and mortality projections**. Upper panels: 1995 age specific fertility rates θ and our projection for 2050 (left) and implied Total Fertility Rate (right). Intermediate panels: Age survival probabilities S_i in 1995 and our projection for 2050 (left); and associated life expectancy time series (right). Bottom panels: immigrants flows (left) and immigrant share on total population (right).

The 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 curve of age specific conditional survival probabilities. The figures implemented in our simulations are the average growth rate of the Spanish population in the time interval 70/95 (n=0.0571%) and the survival probability implicit in INE mortality tables for 94/95.

4.2 Economic model

4.2.1 Functional forms and parameters

Preferences All individuals in the economy share the same period utility function: a separable CES function, with unitary elasticity of substitution, ie:

$$u(c_i, l_i) = log(c_i) + \sigma\, log(l_i)$$

We confined ourselves to the logarithm case is order to guarantee that all discrete decisions are constant in a final steady state including exogenous technological growth.[23] Therefore, we fully specify the individual preferences by choosing the values of σ and β.

Heterogeneity We consider J different educational types, characterized by their life cycle productivity ($\varepsilon^t_{i,j}$) and leisure ($l^t_{i,j}$) profiles. Under Labour Augmenting technological growth, $\varepsilon^{u+i-1}_{i\,j}$ specializes to a unique life cycle productivity profile $\varepsilon_{i\,j}$, which is shifted upwards with calendar time by the technological growth. In contrast, the age profile of hours worked is going to be constant among cohorts. Both processes are parametrized with the help of quadratic curves, which implies a total of $3 \times J$ parameters to be calibrated. It is also needed to fixed the distribution by education, ω^t_j, which we take as constant both within and across cohorts.

Technology We represent the aggregate technology with a standard Cobb-Douglas production function in capital and efficient labour units ($Y = K^{\zeta}\, L^{1-\zeta}=$).[24] We assume there are no adjustment cost, that capital depreciates at a constant rate δ and that productivity grows at a constant rate ρ.

Public Institutions To describe the government policy in our model we must specify (1) the parameters of the pension formula ($\tau_m, \tau_N, \alpha_0, \alpha_1$ and D), (2) the contribution rate ς and (3) the functions determining the annual values of the minimum pension and public consumption. In both cases we assume very simple rules: the minimum pension is 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.[25]

[23] 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 (2000) for the Spanish case.)

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

[25] 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

	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

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

	data	model	parameters
$rK/Y\%$	34.7	34.7	$\zeta = 0.347$
K/Y	2.57	2.59	β= 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	$\rho = 2.12$

Table 5: Calibration to the Spanish economy 1970/1995: macroeconomic targets and parameter choices.

4.2.2 Calibration targets and parameter choices

Our modeling choices in the previous section implies that we must choose the values of a total of 32 parameters to compute the equilibrium of our model.[26] In this section we show how these values are assign in an attempt to reproduce our calibration targets **(ii)** to **(v)**.

- **(ii)** Public pension system

  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 pension to average pension ratio (0.77).[27] The contribution rate value has been 28.3% for more than a decade.

- **(iii)** Macroeconomic aggregates.

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.

[26]This number depends on the number of educational levels considered. For the database we use to calibrate the earnings and hours profiles (ECHP94), the optimal number is J=3. Therefore, 2 parameters describe household preferences, 20 describe the earnings and hours process, 3 describe the aggregate technology and 7 parameters describe the government policy.

[27]0.77 is the minimum pension to average pension ratio in the time interval 80/95 for early retirees with a dependent spouse.

We choose β and δ to target the average capital to output and investment to output ratios during our calibration interval 70/95. 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 result of these choices is shown in table 5.[28]

- **(iv)** 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 78/95 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 6). This behaviour implies an average retirement age in the model of 63.69, just a little higher than the value observed in the data.

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

  We obtain all the information about income, hours worked and education from the 1994 cross section of the ECHP. In this database can be precisely identify up to three educational types: High (j=1), Average (j=2) and Low (j=3). Their empirical distribution is presented in the second column of the table 6.[29] The productivity and hours profiles for each educational type have been estimated from data on gross labour earnings, hours worked and employment rates.[30] The results can be appreciated in figures 15 and 16 (in the appendix).

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 and from the information in table 6 we conclude that the model approximately reproduces the stylized facts

[28] The labour income share is taken from Puig & Licandro. The figure for the stock of capital is the 70/95 average of the estimation in the database "Sophinet" of Fundación BBV, 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 Income and Product Accounts (CNA86).

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

[30] Our estimations correspond to average profiles in the entire working-age population, as we do not include unemployment or non participation in the model. Our 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 them we get the empirical profiles of hours worked by age for each of our educational types. The profiles included in the model are a smoothed (quadratic) version of the empirical one, fitted by OLS. The productivity profiles have been recovered in a similar way. We first estimate the age profile of labour income for employed workers by education. We then compute the empirical profiles for our representative agents by weighting them with the employment rate. Again, The profiles included in the model are a smoothed (quadratic) version of the logarithm of the empirical one, fitted by OLS.

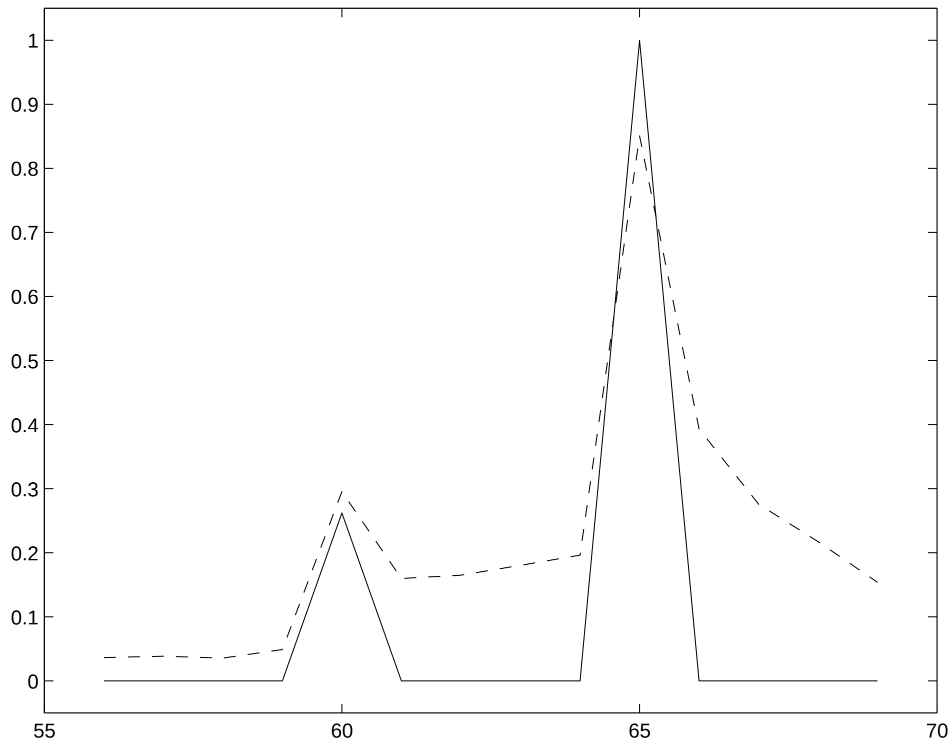

Figure 6: Retirement hazard in the initial steady state (-) and in the data (–) HLSS-95

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 6: Initial equilibrium: optimal retirement ages τ, starting binding age for minimum pension $J(\tau)$; optimal binding age for the borrowing constraint $\bar{t}(\tau)$, internal rates of return for social security contributions and share of the pension expenditure by educational type.

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

Table 7: Public pension system indicators: share of pensions affected by the minimum pension mechanism ($\% bm$), and pension expenditure, contribution and deficit ratios to aggregate output.

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.

Secondly, in table 7 we compare the aggregate levels of the pension system in the model and in the data. We can see that the model clearly overstates the magnitude of the expenditures and revenues of the system.[31] Several elements compound to that result. Firstly, there is a significant number of old age pensions computed according with the rules of other regimes (self employed, farmers, public servants) or of actually extinguished schemes (SOVI). In most cases, these excluded schemes have lower pension to income and contribution to income ratios than 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 and the penalty for insufficient contributions are best exponents of these 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 can also contribute to the observed discrepancy. It is clear than, in any case, all the model predictions about the *levels* of the pension system must be taken with great care. We must bear in mind, however, that our basic question is the *relative* performance of the system 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 present the economic results, starting in section 5.2 with a brief discussion 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 present a description of the two basic reform strategies explored in the paper. Finally, their effects are reviewed in the section 5.4.

[31] The figures come from "Cuentas Integradas de Protección Social", Anuario de Estadísticas Laborales-1999, and refer to 1998. The discrepancy is even higher if the 89/97 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.

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 figure 7. The number of the elderly increases all along the simulation, although at a changing rate. The collective of those over 60 goes up from 7 to 8 millions between 2000 and 2015, from 8 to 10 between 2015 and 2032 and from 10 to 12 between 2032 and 2045, slightly decreasing in size afterwards. The size of those in working age, in contrast, reaches its maximum in 2011 and decline steadily from that date onwards. 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 figure 7). This figure is a good summary of the magnitude of the aging process. Another way to visualize the dramatic change in the age distribution of the population during the first half of the century is by comparing the population pyramid in different years. Such a comparison is shown in the right bottom panel of figure 7 for 2000 and 2040. The changes are so sharp that need no additional comments.

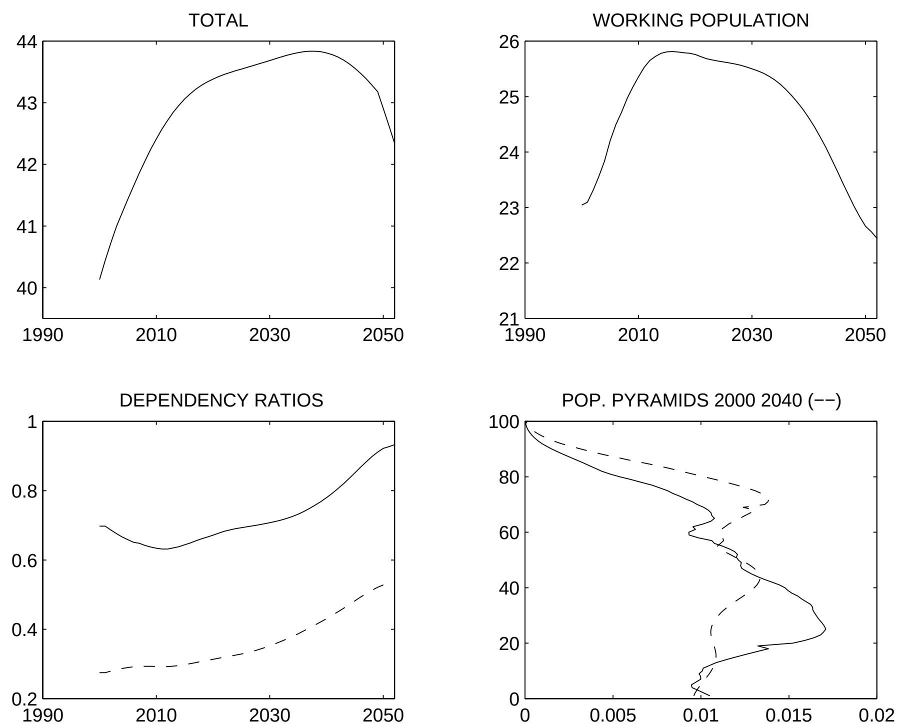

Figure 7: Population Projections: total and working population, total (-) and old age (- -) dependency ratios and population pyramids in 2000 (-) & 2040 (- -).

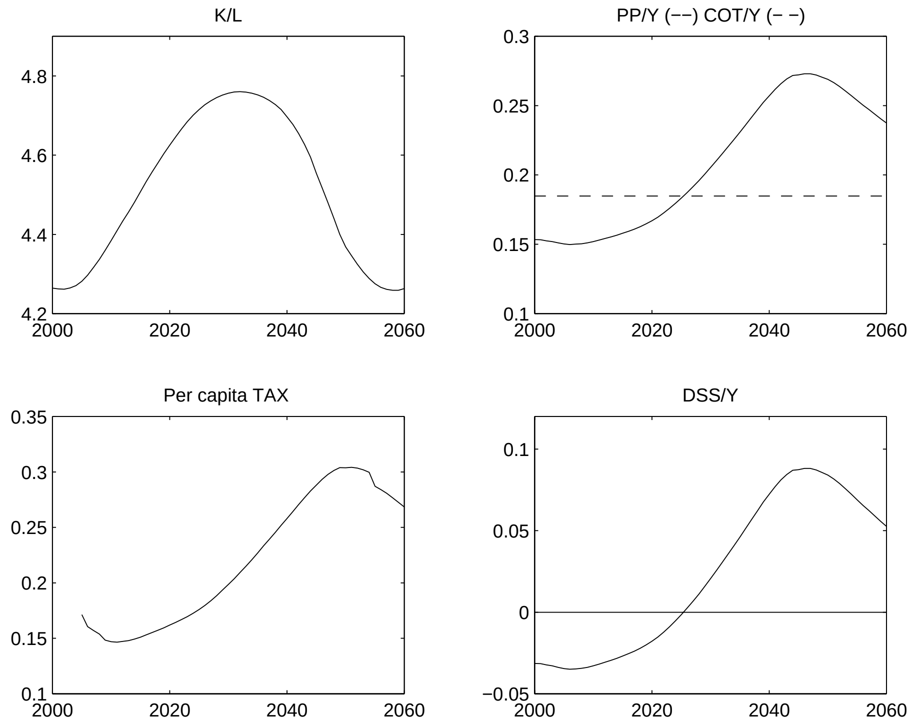

Figure 8: Base simulation: main macroeconomic and pension system indicators.

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 basic features of the aggregate performance of our model economy in this case are as follows. The output growth rate slows down 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. Figure 8 and the first column of table 11 (all result tables are confined to the appendix) show the evolution of the relative scarcity of both inputs all along the transition path. We can see a process of significant capital deepening which ends up in 2038 and reverses for the rest of the period.[32] Social security financial balance undergoes a striking change, as the size of the pension expenditure almost doubles between 2010 and 2045 (upper right panel of figure 8 and first column of table 13). Under those conditions, the initial surplus of the system can only be sustained until mid twenties (first column of table 14). After 2026, the system runs into deficit, peaking at a 8.7 % of the aggregate product in 2048. The fiscal burden suffered by the agents of the economy should doubles in order to cope with

[32]This is a result of the interaction between the changes in the age distribution of the population and the different age profiles of labor supply and assets holdings (compare the life cycle profiles of productivity and accumulated assets in figure 17 in the appendix).

the pension system imbalance (lower left panel in figure 8).[33]

The differences in the life cycle behaviour by educational type are illustrated in figure 17 (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 behavioural pattern. The Spanish pension system imposes a very substantial redistribution of income along the individual life cycle. This is implemented through very high contribution taxes and very generous pensions (the replacement rate over *net* labor income is higher than a 100% in all cases). There are substantial differences in the *level* and *dynamics* of life cycle labor income depending on the educational level. In particular, the concavity of the income profile is much more acute for highly educated workers. Finally, there is considerable variation in the 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). Surprisingly, the prohibition to borrow from future pension income becomes binding at a very close age for all type of workers (fifth column in table 6 .

5.3 Parametric reforms

As we briefly described in section 1, we consider four variations to the institutional environment existing before 1997. In first place, we reproduce the basic changes introduced in 1997, 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). This changes are far from the generosity cuts implemented in other countries, which is highly paradoxical in light of the severity of population aging in Spain.[34] In our view, the real reforms are still waiting to be undertaken. In this paper we explore two possible ways of 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 particular, we consider a further increase in D from 15 to 30. The new parametric values after this change are denoted as R97+.[35]

- A delay in *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.[36] We refer to this new pension system as $\tau_N = 67$.

[33]For an easier interpretation, the fiscal burden is presented through $\overline{\varphi}^t$, the intragenerational average of the annual lump sum tax to gross income ratio.

[34]The latest legislative changes, introduced in 2001 and due to be implemented in 2002, do nothing to remedy this situation (as the OECD report for the Spanish economy OECD (2001) stresses).

[35]A change of this type is now under heavy discussion in Spain. There is, in fact, a high probability that this reform will be actually implemented during 2003.

[36]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.

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

5.4 Impact of parametric reforms

The aggregate effects of the reforms described in the previous section are illustrated in the figures 9 to 10 and summarized in the tables 11 to 14 (in the appendix). Their impact on the pensions received by the different agents of the economy is presented in tables 8 to 10 (again confined to the appendix). Finally, figures 12 to 14 show the welfare effects of the reforms for the different agents of the economy.

5.4.1 1997 Reform

The increase in the number of years included in the Regulatory Base has effects of opposite sign on the individual benefit depending on the dynamics of labor income. Highly educated workers, who experience remarkable drops in their earnings at advanced ages, tend to get higher pensions after the reform, while low income workers (with flatter labor income profiles) tend to suffer reductions in their final benefits. In both cases the size of the changes is moderate. For average educated workers, on the other hand, there are hardly any changes. These modifications are not large enough to induce adjustments in the retirement behaviour of the agents (left lower panel of figure 9). On aggregate, the average pension slightly rises (right lower panel of 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.

In order to analyze the impact of the reform on the financial sustainability of the pension system, we use the following accounting identity:

$$\frac{DSS}{Y} = \frac{g}{\overline{y}}\, d = \left(\frac{\overline{b} - \overline{cot}}{\overline{y}}\right)\left(\frac{s}{e}\right) \tag{13}$$

where $\overline{b}$ and $\overline{cot}$ stand for the average pension and contribution per retired worker, $\overline{y}$ is the average per worker product, s represents the share of the elderly in total population, e is the employment rate and d is the ratio of retired to employed people. $g/\overline{y}$ can be interpreted as an indicator of the cross-section generosity implicit in the pension system, while d is an effective dependency ratio. This identity is useful to identify whether the impact of any reform operates through changes in the system's generosity, changes in the dependency ratio or both. Figures 10 and 11 present the changes induced by the different reforms on the two components of the accounting identity. We can see there that 1997 reform slightly increases the generosity of the system while leaving the dependency ratio unaltered. This results in a 0.5% rise in the pension expenditure to output ratio. and a very small upward shift in the time series of social security deficit and taxes (tables 12 and 14).

We evaluate the welfare impact of the reform by computing its associated compensating variation (CV).[37] Most cohorts of high income workers benefit from the higher pensions resulting from the reform (figure 12). All the other individuals experience small welfare

[37] We define the Compensating Variation (CV) 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 reforms.

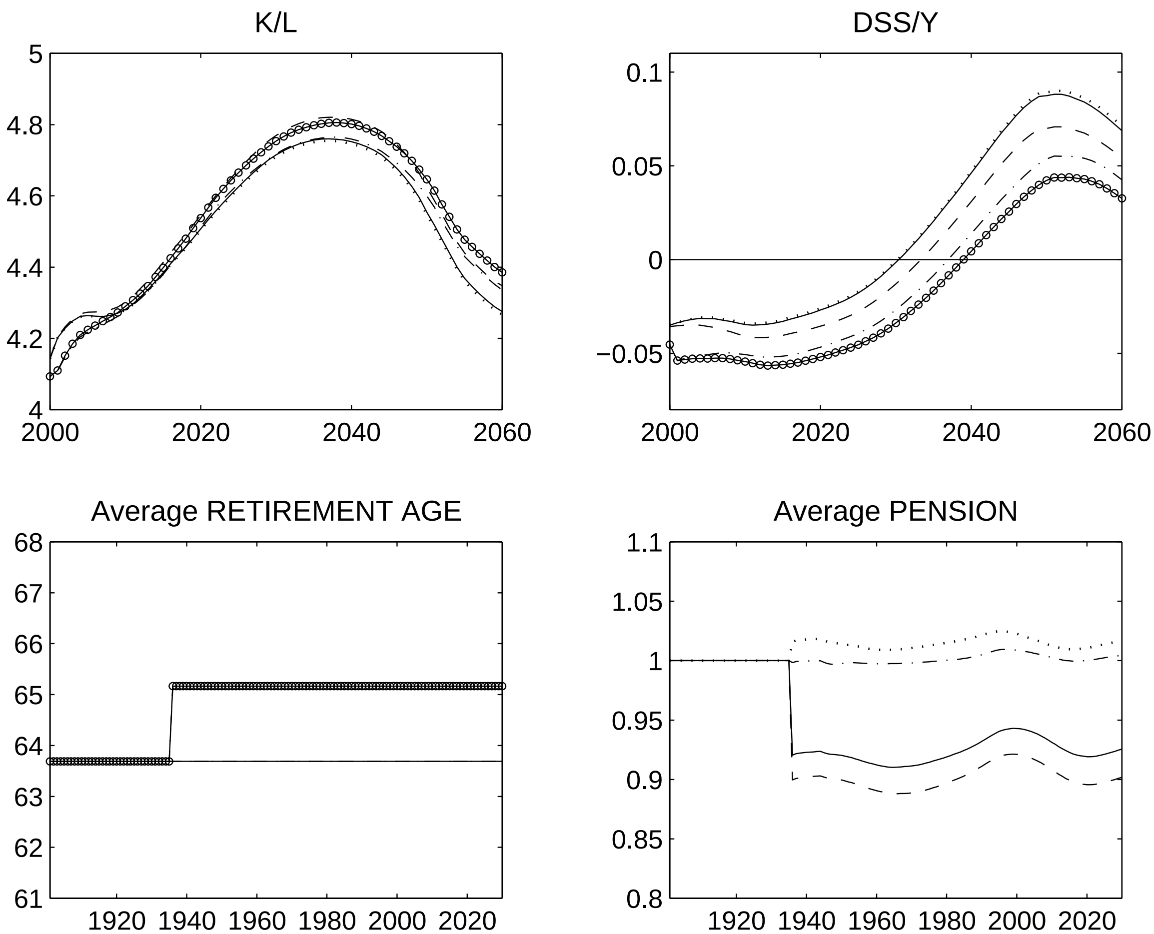

Figure 9: Time series for K/H, DSS/Y and average retirement age in our sequence of simulations: Base (–), R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double reform (•). Right lower panel: ratio b^R/b^B of the average pension prevailing after the reforms (R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–)), to the average pension in the base simulation.

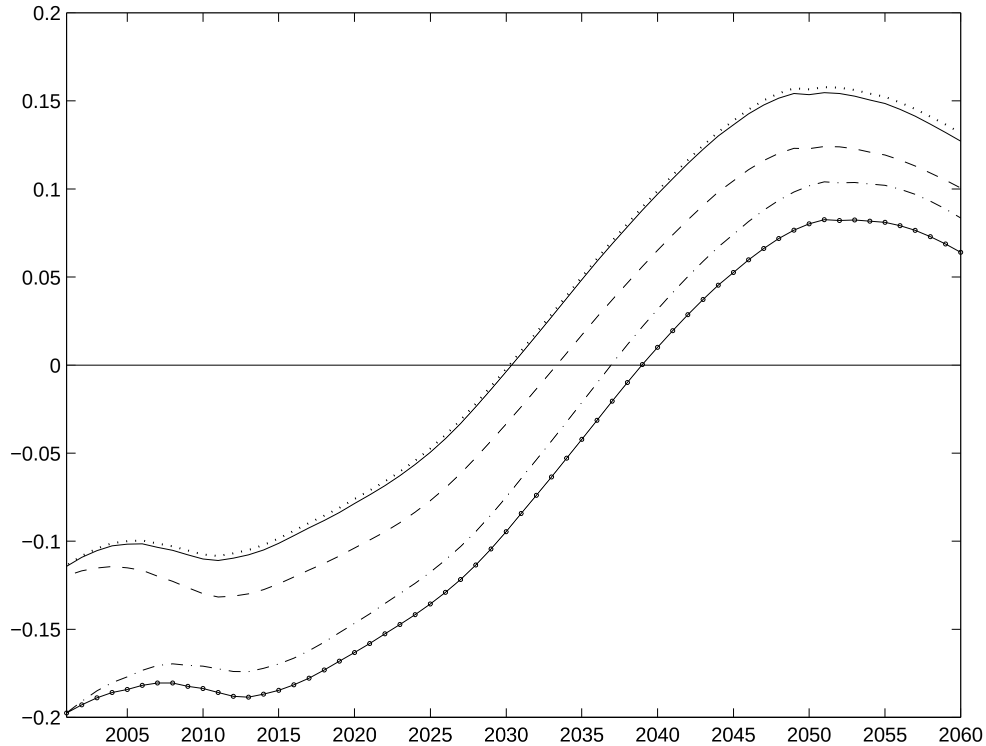

Figure 10: Pension system generosity index $\frac{\bar{b}-\bar{c}}{\bar{y}}$ in our sequence of simulations: base (-), R97 ($\cdot$), R97+ (- -), $\tau_N = 67$ (-.-) and Double ($\bullet$)

.

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).

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 the final pensions. The losses are around a 10% reduction for both high a low educated workers, while average educated workers experience more moderate drops. 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 generosity of the system (figures 11 and 10).

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), which leads to

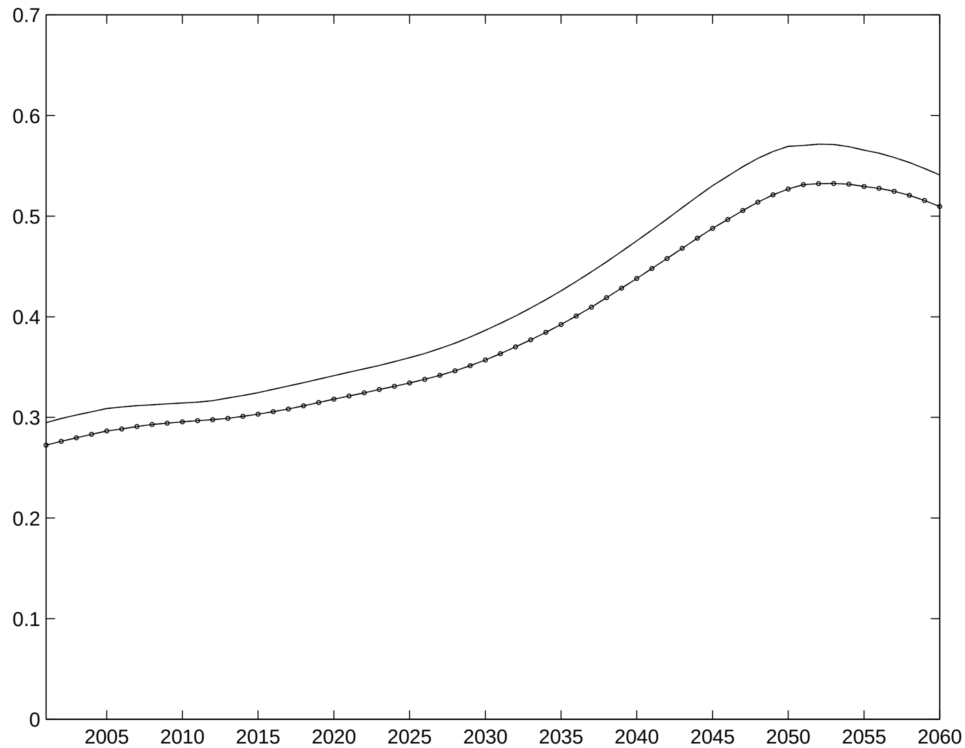

Figure 11: Effective dependency ratio in our sequence of simulations: base (-), R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (•).

an absolute reduction in the pension system deficit (DSS/Y) ranging from 0.6 to 1.75 percentage points.

Finally, there is substantial heterogeneity in the welfare impact of the reform. For most alive cohort at the time the reform is implemented, the associated positive effects (lower taxes and higher labor income) do not compensate for the lower pensions perceived. This is the case for individuals of high education born between 1936 and 1988, and for individuals of average education born between 1936 and 1968. Younger cohorts of both types of individuals and all the low educated workers (protected by the minimum pension scheme) benefit from the reform.

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

When the normal retirement age is delay 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 public pension is available. The generosity of the system is also affected by this legislative change and its behavioural consequences. Those who delay their retirement experience a reduction in their final pensions as a result of the decreasing profile of earnings at advanced ages. Those who early retire should suffer much more severe reductions in their initial pensions, as the new rules implies an increase in early retirement penalties. Minimum pensions, however, can make these workers elude any pension reduction. Overall, both the dependency ratio and the generosity of the system are reduced by the reform (see figures 11 y 10).

The impact on the financial condition of the system is important: the drop in pension expenditure range from 10 to 14 %, allowing reductions in the deficit to output ratio ranging form 1 to 3 absolute points. This latter effect is also a consequence of a slight capital deepening of the economy from the third decade of the century onwards.[38]

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. [39] In any case, 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 12 and 13).

5.4.4 The "Double" Reform

We have finally considered the simultaneous implementation of the two basic strategies: increase the averaging period to cover the 30 years before retirement and delay the normal retirement age 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 this Double reform reduces the initial pensions a great more deal than in the previous τ_N=67 reform. It is also the most effective reform in terms of the reductions in the pension expenditure (around 18%) and in the pension system deficit (2 to 4.5 absolute percentage points). This allows larger tax cuts than in any of the previous reforms. It also generates a substantial capital deepening, although not as strong as in R97+ (in the short run). These positive effects compensate for the negative impact of the lower pensions for middle age agents, but are not enough for older active workers at the time the reform is implemented. As usual, low educated workers escape from any welfare loss thanks to the minimum pension scheme.

6 Concluding comments

In this paper we construct an OLG model, calibrate it to the Spanish economy and find that it approximates the basic stylized facts of retirement behaviour in Spain. The model is then used 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 have strong intragenerational effects and are utterly incapable of helping the system to cope with the effects of population aging.

[38]This is a result of the remarkable generosity of the Spanish pensions. When individuals delay retirement their life cycle wealth goes *down* (unless they receive minimum pensions), which leads to lower life cycle consumption and higher savings.

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

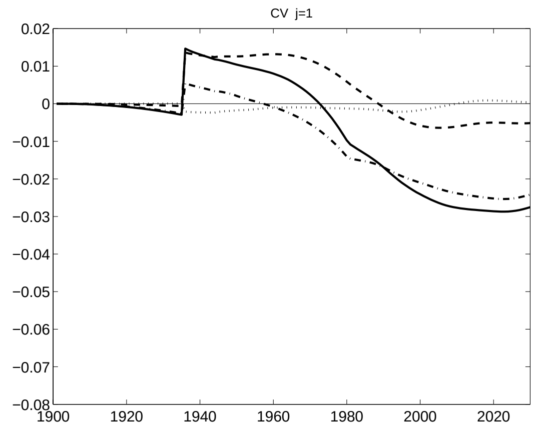

Figure 12: Compensating variation with respect the Base simulation in our sequence of reforms: R97 (·), R97+ (- -), $\tau_N = 67$ (-.-) and Double (–). High educated worker.

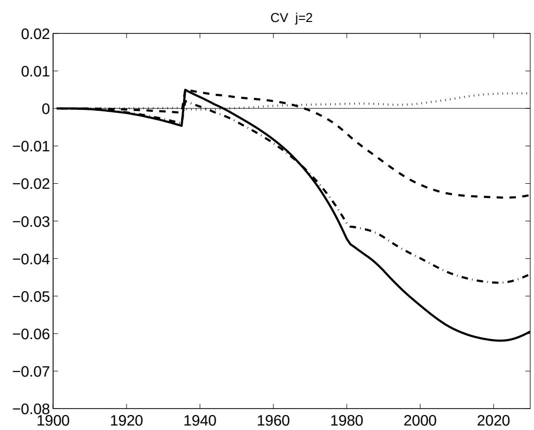

Figure 13: Compensating variation, average educated worker.

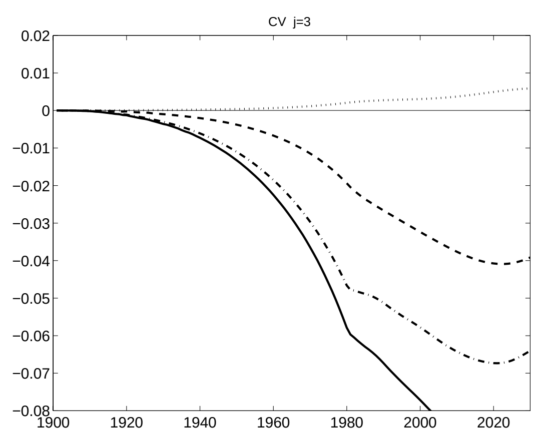

Figure 14: Compensating variation, low educated worker.

- 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 imbalance. 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 modeling process.[40] In particular, the following lines of research deserve to be seriously considered in the future. 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 is, however, a major challenge to our current modeling 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 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 evolution of the pension system financial condition.

[40]They are actually robust to changes in the way the fiscal system or the public consumption are modeled. They are also robust to the elimination of the general equilibrium effects (ie, to the "close" economy assumption).

APPENDIX

u	Base	R97	R97+	$\tau_N = 67$	Todas
1901	5.54	0.00	0.00	0.00	0.00
1921	5.66	0.00	0.00	0.00	0.00
1941	5.64	1.81	-9.78	-0.04	-7.70
1961	5.76	0.92	-11.01	-0.26	-8.84
1981	5.86	1.55	-10.19	0.05	-8.01
2001	5.65	2.18	-7.93	0.85	-5.73
2021	5.76	1.11	-10.45	0.05	-8.09

Table 8: $b(u)$ in the Base Simulación and $log\,[b^R(u)/b(u)]$ with the successive reforms for j= 1

u	Base	R97	R97+	$\tau_N = 67$	Todas
1901	2.98	0.00	0.00	0.00	0.00
1921	3.04	0.00	0.00	0.00	0.00
1941	3.03	0.56	-7.60	-0.33	-6.01
1961	3.09	-0.29	-8.89	-0.55	-7.21
1981	3.15	0.35	-8.04	-0.22	-6.33
2001	3.04	0.96	-5.63	0.56	-3.95
2021	3.10	-0.10	-8.30	-0.23	-6.40

Table 9: $b(u)$ in the Base Simulation and $log\,[b^R(u)/b(u)]$ in the successive reforms for 2

u	Base	R97	R97+	$\tau_N = 67$	Todas
1901	1.45	0.00	0.00	0.00	0.00
1921	1.48	0.00	0.00	0.00	0.00
1941	1.48	-4.87	-10.77	-19.16	-29.99
1961	1.49	-5.31	-11.28	-19.54	-30.56
1981	1.53	-5.16	-11.44	-19.35	-30.59
2001	1.49	-4.11	-8.75	-18.11	-28.35
2021	1.50	-5.48	-10.89	-19.37	-29.99

Table 10: $b(u)$ in the Base Simulation and $log\,[b^R(u)/b(u)]$ in the successive reforms for 3

	Base	R97	R97+	$\tau_N = 67$	Todas
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 11: **K/Y** in the base simulation and changes induced by the reforms.

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

Table 12: average **tax burden** $\overline{\varphi}$ in the base simulation and changes induced by the reforms.

	Base	R97	R97+	$\tau_N = 67$	Todas
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 13: **PP/Y** in the base simulation and changes induced by the reforms.

	Base	R97	R97+	$\tau_N = 67$	Todas
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 14: **DSS/Y** in the base simulation and changes induced by the reforms.

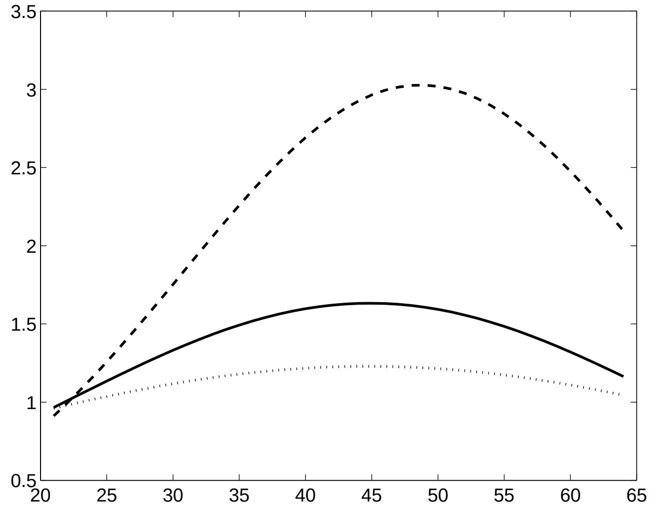

Figure 15: Life cycle income profile by educational type: High (- -), average (-.-) and low (·). Source: ECHP94

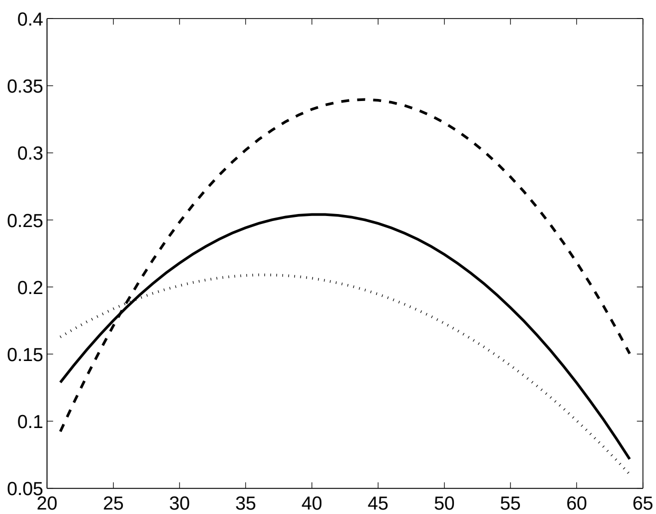

Figure 16: Life cycle profile of hours worked by educational type: High (- -), average (-.-) and low (·). Source: ECHP94

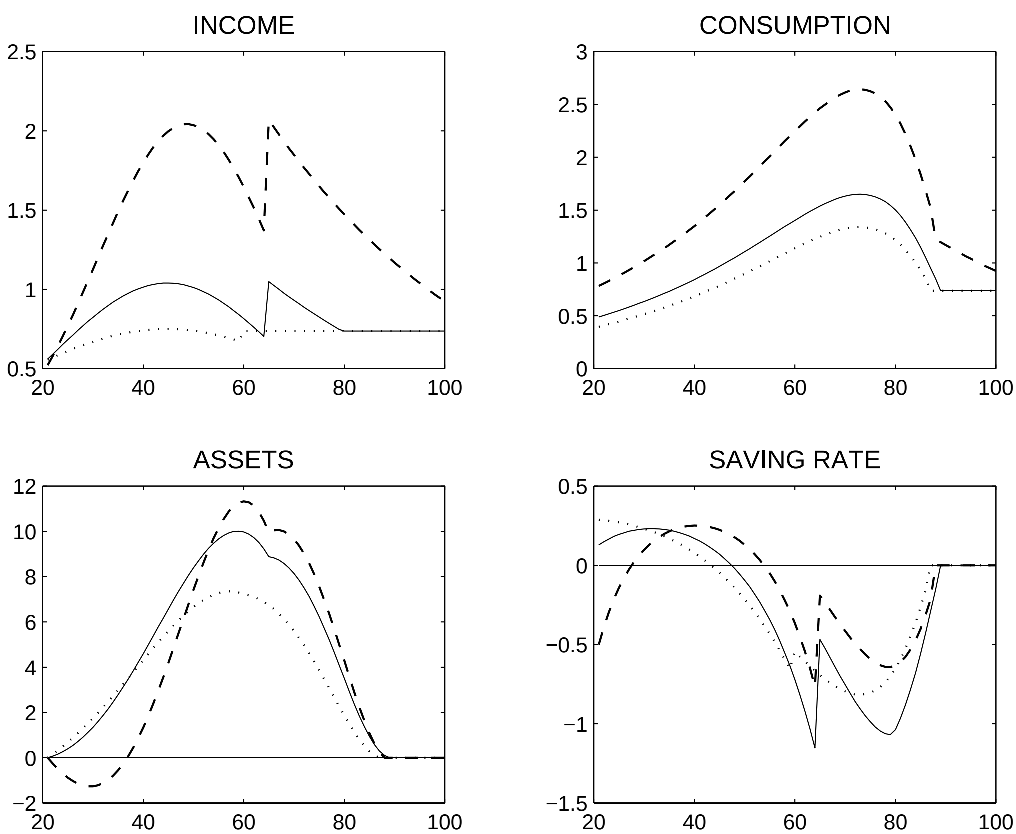

Figure 17: Base Simulation: life cycle behaviour for the cohort born in 1970 by educational type: low (·), average (-) and high (- -). (All variables deflated of productivity growth).

References

Auerbach, A. J. and L. J. Kotlikoff (1987). *Dynamic Fiscal Policy*. Cambridge University Press.

Auerbach, A. J., L. J. Kotlikoff, R.P. Hagemann, and G. Nicoletti (1989). The economic dynamics of an ageing population: the case of four OECD countries. *OECD Economic Studies*, **12**, 97–130.

Boldrin, Michele, Sergi Jiménez, and Franco Peracchi (1999). Social security and retirement in spain. In Jonathan Gruber and David Wise (Eds.), *Social Security and Retirement around the world*, pp. 305–353. NBER: University of Chicago Press.

Boldrin, Michele, S. Jiménez-Martín, and Franco Peracchi (2001). *Sistema de pensiones y mercado de trabajo en España*. Fundación BBV.

Chauveau, Thierry and Rahim Loufir (1997). The future of public pension in the seven major economies. In D. Peter Broer and Jukka Lassila (Eds.), *Pension Policies and Public Debt in Dynamic CGE models*, pp. 16–73. Physica-Verlag in association with ETLA.

Conesa, JC. and C. Garriga (1999). Sistema fiscal y reforma de la seguridad social. *Cuadernos Economicos de ICE* (65).

Crawford, Vincent P. and David M. Lilien (1981, August). Social security and the retirement decision. *Quaterly Journal of Economics*, 505–529.

De Nardi, MC, S İmrohoroğlu, and T. Sargent (1999). Proyected US demographics and social security. *Review of Economic Dynamics*, **2**, 575–615.

Diamond, Peter and Jonathan Gruber (1999). Social security and retirement in the united states. In Jonathan Gruber and David Wise (Eds.), *Social Security and Retirement Around the World*, pp. 437–473. NBER: University of Chicago Press.

Fabel, Oliver (1994). Social security, optimal retirement and savings. *European Journal of Political Economy* (10), 783–802.

Gruber, Jonathan and David Wise (1999). *Social Security and Retirement around the World*. NBER.

Hurd, Michael D. (1989, July). Mortality risk and bequest. *Econometrica*, **57**, 779–813.

INE (1995). *'Proyecciones de la Población de España calculadas a partir del Censo de Población de 1991*. INE.

Jiménez, Sergi, JM Labeaga, and M Martínez (1999). Health status and retirement decisions for older european couples. mimeo.

Jiménez-Martín, Sergi and Alfonso R Sánchez-Martín (2000). A partial equilibrium evaluation of the effects of minimun pensions on retirement. mimeo.

Kalisch, D.W. and T. Aman (1998). Retirement income systems: The reform process across OECD countries. Awp3.4, OECD.

Kenc, Turalay and William Perraudin (1997a). European pension systems: a simulation analysis. *Fiscal Studies*, **18**, 249–277.

Kenc, T. and W. Perraudin (1997b). Pension systems in europe: A general equilibrium study. In D. Peter Broer and Jukka Lassila (Eds.), *Pension Policies and Public Debt in Dynamic CGE models*, pp. 75–109. Physica-Verlag in association with ETLA.

Leung, Siu F (2000). Why do some households save so little? a rational explanation. *Review of Economic Dynamics*, **3**, 771–800.

Miles, David (1999). Modelling the impact of demographic change upon the economy. *The Economic Journal* (109), 1–36.

OECD (2001, june). Oecd economic surveys. spain. Technical report, OECD.

Rios-Rull, Victor (1994). Population changes and capital acumulation: The aging of the baby boom. mimeo.

Rojas, Juan. (2000). El sistema de pensiones y las proyecciones de población: una evaluación cuantitativa. *Cuadernos Económicos de ICE* (64), 171–188.

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

Sánchez-Martín, Alfonso R (2002). Jubilación endógena y reforma del sistema público de pensiones en España. Tesis Doctoral, Universidad Carlos III de Madrid.