A Parametric Reform of the Spanish Public Pension System*

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Abstract

I consider a theory based on households that differ in their education, receive an uninsurable, idiosyncratic endowment of efficiency labor units, and face health and survival risks. Households also understand the link between the payroll taxes they pay and the public pensions that they receive, and decide when to retire from the labor force. I calibrate this theory to the Spanish economy so that it replicates its demographic features, its macroeconomic aggregates and ratios, the Lorenz curves of its income and earnings distributions, and many of its institutional features. I show that this theory accounts for the retirement behavior of Spanish households almost exactly. I then use the model economy to study the aggregate, distributional, retirement and welfare consequences of increasing the number of years of contributions that are used to compute the pensions, and I evaluate this policy reform in the context of both the Spanish demographic and educational transitions. I find that the reform increases the stock of capital by 6.3 percent, and output by 1.6 percent, but it decreases consumption per capita by 2.6 percent. The average pension decreases by more than 19 percent, and the average retirement age from 61.9 to 60.9 years. The reform also reduces the Social Security deficit from 8.6 to 5.4 percent of GDP in the year 2050. Finally, I find that the welfare loss for the population alive at the moment of the reform is 2.5 percent of lifetime consumption.

JEL CLASS.: C68, J26, H55
KEYWORDS: Computable General Equilibrium, Retirement, Social Security Reform

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1 Introduction

*The Project* — The future financial viability of pay-as-you-go pension systems is in doubt for two main reasons: the aging of the populations and the trend of workers to retire at younger ages. Consequently, in the next few decades, the retiree to worker ratios of developed economies will increase significantly and the current unfunded pension systems will no longer be financially viable. There is another trend which should affect the financial situation of unfunded pensions systems. Specifically, workers become more educated. This *educational transition* is also important because more educated workers both pay higher payroll taxes and collect higher pensions.

This article has two purposes. First, I design a model economy that replicates the basic facts of the retirement behavior of Spanish households, and many of the aggregate, distributional and institutional features of the Spanish economy. Second, I use the model economy to study the aggregate, distributional, retirement and welfare consequences of extending the number of years of contributions used to compute the pension benefits from the current fifteen years to the entire working life of the households, in the context of both a demographic and an educational transition.

*Facts* — Between 1957 and 1977, the average number of children per Spanish women was 2.8. Since 1980, this number has decreased continuously, and in 1998 it was only 1.16. This change in fertility will change the retiree-to-worker ratio of the Spanish economy very significantly. In 1997 in the Spanish economy there were 23 retirees for every hundred workers and, according to the projections of the Spanish *Instituto Nacional de Estadística*, by the year 2050 there will be no less than 60. Since the Spanish Public Pension System is unfunded, this ageing process of the Spanish population will have significant effects on its future financial viability.

The financial strain on Spanish public pensions has been compounded by another trend: as in most of developed countries, Spanish workers are retiring earlier. If in 1980 the participation rate of male Spanish workers between ages 55 and 64 was 77 percent, in 1995 this number was only 55 percent. The main explanation of this change is that social security benefits themselves provide large incentives to leave the labor force early. For instance, Sánchez Martín (1999) finds that the minimum retirement pension benefit provided by the Spanish *Régimen General de la Seguridad Social*, creates a strong incentive for workers to retire as early as possible.1

Another important fact concerning the Spanish population is that in the last thirty years, Spanish households became significantly more educated. Specifically, in 1977 around 9 percent of Spanish working age people had high school studies and 3 percent had college studies. Twenty years later, in 1997, these shares were 24 percent and 13 percent. In 2050, according to Meseguer (2001), they are projected to be 38 percent and 24 percent. This educational transition is also important for the financial viability of the pension system, because more educated workers both pay higher payroll taxes and collect higher pensions.

*A modelling question* — In this paper, I ask if I can provide a theory that accounts for the retirement behavior of Spanish households. The theory I am looking for should be based on the optimal choices of households who are heterogeneous in their education levels, who face an uninsured idiosyncratic process in their endowments of efficiency labor units, and who decide when to retire optimally. Households also face health and survival risks.

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1The *Régimen General de la Seguridad Social*, is the most important public pension system in Spain. For instance, in 2001, 73.9 percent of all workers belonged to this regime.
I find that I can provide such a theory. Specifically, I show that a model economy that replicates the main Spanish macroeconomic aggregates, the Lorenz curves of the Spanish distributions of income and earnings, and the main institutional features of the Spanish economy also accounts for the retirement behavior of Spanish households almost exactly.

A policy question — I also ask what will be the aggregate, distributional, retirement and welfare consequences, of increasing the number of years of contributions that are used to compute the Spanish pensions from the last 15 years of the current system to the entire working lifetimes of the households in the reformed economy. In the model economy, this reform is announced and implemented in 2005, and the new rules only apply to current workers and disabled households.

I find that, in the year 2050 in the reformed economy the average pension of the retirees decreases by 19 percent. This is because in the reformed economy the early years of the working lives of households, which is when they are least productive, are used to compute the pensions. I also find that the average retirement age decreases from 61.9 to 60.9 years. As a consequence, the Social Security deficit decreases from 8.6 percent of the model economy output under the current system to 5.4 percent under the reformed system. This improvement in the financial condition of the pension system implies that a smaller consumption tax rate is needed to balance the government budget. Specifically, the consumption tax rate decreases from 40.1 percent before the reform to 37.3 percent after the reform. The reduction in the pensions results in a capital stock that is 6.3 percent higher. This is because public pensions are an imperfect substitute of private savings. Finally, I find that the reform brings about an increase of 1.6 percent in output but a decrease of 2.6 percent in consumption. Consumption decreases in part because the reduction in the consumption tax rate cannot compensate the reduction in pensions.

The reform changes the average value of pensions, and it also changes the retirement behavior of households. This is because after the reform more households are left with the minimum pension, and this minimum benefit plays a very significant role in the retirement decision. Specifically, under the current system every worker is entitled to receive the minimum pension regardless of the number of years during which he has contributed to the system. Moreover, since minimum pensions are exempt from early retirement penalties, the strong incentives to work associated with these penalties disappear. Consequently, every worker who is only entitled to a minimum pension chooses to retire at age 60 (the earliest possible retirement age) both in the benchmark and in the reformed economies.

The reform brings about a welfare loss of 2.5 percent of lifetime consumption to the households that are alive at the moment of this policy change. Finally, I find that the proposed reform has no significant effects on earnings and income inequality.

Policy reform: previous answers — The ability of parametric reforms to reduce the burden of demographic changes has been subject of a large body of previous research. For instance, De Nardi, Imrohoroglu, and Sargent (1999) study the consequences for the U.S. economy of increasing the compulsory retirement age in four years. This analysis is implemented in a large scale overlapping generations model where households face idiosyncratic lifetime and labor productivity uncertainties. Their findings are that the reform reduces the size of the fiscal burden and, therefore, the consumption tax required to finance it from 36.9 to 31.2 percent. For the Spanish economy, Arjona (2000) finds that at the end of the demographic transition, the pension benefit must be reduced by 33 percent of its 1995 value in order to keep the payroll tax rate and the pension system deficit constant. Finally, and also for the Spanish case,
Sánchez Martín (2003) explores various parametric reforms that increase both the number of years of contributions used to compute the pension and the compulsory retirement age. He finds that the best of these parametric reforms reduces the deficit of the pension system from 9 to 5 percent of the model economy output.

The model economy — This paper combines various features of model economies described elsewhere in the literature. I consider an overlapping generation model where households differ in their education as in Cubeddu (1998), face stochastic lifetimes as in Hubbard and Judd (1987), and face an uninsurable idiosyncratic shock to their endowments of efficiency labor units as in Conesa and Krueger (1999). Moreover, the households understand the link between payroll taxes and pensions as in Hugget and Ventura (1999), and make endogenous retirement decisions as in Sánchez Martín (2002). Finally, households also face health risk.

Three important features distinguish my paper from those in the literature. (i) my benchmark model economy replicate the stylized facts of retirement behavior of Spanish households. This is important for two reasons: as we will see in the next section, formal previous attempts to account for the facts that characterize early retirement behavior had little success. And second, we can analyze the consequences of any social security reform on the households’ retirement behavior. (ii) I calibrate my model economy to the Lorenz curves of Spanish income and earnings as reported by Budría and Díaz-Giménez (2004). This has also two implications: this allow me to obtain a process on earnings that is consistent with both the aggregate and the distributional data on income and earnings. But more important, it also enables me to analyze the distributional consequences of any social security reform, an issue from which the literature on social security has generally abstracted. (iii) And finally, together with a demographic transition, I introduce an educational transition to the model economy. Specifically, workers become more educated. This is also important because more educated workers both pay higher payroll taxes and collect higher pensions. I measure quantitatively the effect on this educational transition on the social security deficit.

2 The facts and the literature

2.1 Early retirement

In most developed countries workers are retiring earlier. In the past thirty years, this phenomenon has been stronger in Finland, France, Germany, and Netherlands, where the participation rate for those male workers aged between 55 and 64 has decreased to less then 60%, as shown in Table 1. Early retirement has thus complemented the aging process in increasing the ratio of retirees per worker.

\footnote{Fonseca and Soprarseuth (2004) is an exception.}
Table 1: Participation rates of 55-64 male workers (%)

<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Spain</td>
<td>84.2</td>
<td>75.7</td>
<td>62.4</td>
<td>60.3</td>
</tr>
<tr>
<td>Canada</td>
<td>84.2</td>
<td>76.2</td>
<td>64.3</td>
<td>61.0</td>
</tr>
<tr>
<td>Finland</td>
<td>71.1</td>
<td>57.3</td>
<td>47.1</td>
<td>48.1</td>
</tr>
<tr>
<td>France</td>
<td>75.4</td>
<td>68.5</td>
<td>45.8</td>
<td>41.1</td>
</tr>
<tr>
<td>Germany</td>
<td>82.2</td>
<td>65.5</td>
<td>60.5</td>
<td>55.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>80.8</td>
<td>63.6</td>
<td>45.7</td>
<td>51.4</td>
</tr>
<tr>
<td>UK</td>
<td>91.3</td>
<td>81.8</td>
<td>68.1</td>
<td>63.3</td>
</tr>
<tr>
<td>USA</td>
<td>80.7</td>
<td>71.2</td>
<td>67.8</td>
<td>67.3</td>
</tr>
</tbody>
</table>


According to Gruber and Wise (1999), the generous early retirement provisions are responsible for this drop in participation rates. Specifically, they argue that individuals are often induced to retire early because of the large implicit tax imposed on continuing to work after early retirement age\(^3\). An agent’s early retirement decision thus represents the optimal response to the economic incentives provided by the social security system.

Blöndal and Scarpetta (1998) find that the proportion of early retirees in most OECD countries is higher within low and intermediate educational groups. Table 2, shows the participation rates by educational level of those workers aged 60-64, for Spain in 1997.

Table 2: Participation Rates of Spanish Workers Aged 60 to 64 in 1997

<table>
<thead>
<tr>
<th>Education</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-High School</td>
<td>25.9</td>
</tr>
<tr>
<td>High School</td>
<td>38.5</td>
</tr>
<tr>
<td>College</td>
<td>57.7</td>
</tr>
</tbody>
</table>

Source: Spanish Instituto Nacional de Estadística (INE)

However, several studies find that early retirement incentives are related to labor income level and not to the individuals’ educational achievement. For example, Boldrin, Jiménez, and Peracchi (1999) find that in Spain, the implicit tax on continuing to work at the age of 60, is near 86% for a worker in the 10th percentile earnings, and −15% for a worker in the 90th percentile earnings. Also for the case of Spain, Jiménez and Sánchez Martín (1999) find that, while the probability of leaving the labor force is not affected by the labor income level at the age of 65—the normal retirement age—, there is a clear inverse relationship at the age of 60—the early retirement age—, and this relationship is independent of individuals’ education. The next figure shows the conditional probability of retirement for Spanish workers in 1995\(^4\).

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\(^3\)The implicit tax in any period is computed as minus the ratio between the change in the worker’s social security wealth with respect to one year earlier and projected earnings. Social security wealth is the expected present value of the sum of all pensions received until death.

\(^4\)These probabilities are defined as the probability of retiring from the labor force in any period.
The data show two peaks: at ages 60 and 65. At the age of 60, the minimum retirement pension provided by the Spanish public pension system plays a significant role. For instance, Sánchez Martín (2003) finds that 67.7% of Spanish workers retiring at age 60 in 1995 collected the minimum retirement pension. This is because every worker with at least 15 years of contributions is entitled to receive the minimum retirement pension. Moreover, since minimum pensions are exempt from early retirement penalties, the strong incentives to work associated with these penalties disappear. Consequently, every worker who is only entitled to a minimum pension, most of them low income workers, chooses to retire at age 60 and avoid the high implicit tax rate on continuing to work. The peak at age 65 is related to both the lack of actuarial adjustment of pensions after this age and because the foregone pension reaches its maximum at this age.

In conclusion, we have seen that: (i) Early retirement has thus complemented the aging process in increasing the ratio of retirees per worker; (ii) The early retirement provisions are responsible for the drop in participation rates; and (iii) Incentives of early retirement depend on the level of labor income.

2.2 The literature

In spite of the importance of early retirement, formal attempts to account for the facts that characterize early retirement behavior had little success. Specifically, researchers have failed to come up with a quantitative theory that accounts for an average retirement age, participation rates by educational level, and age-dependent conditional probabilities of retirement.

In this section I summarize the findings of Sánchez Martín (2003), and Fonseca and So-praseuth (2004). To my knowledge, these are the only two papers that try to account for the

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5 Another way to exit from the labor market in Spain before the normal retirement age is achieved by drawing on disability pensions. See Boldrin, Jiménez, and Peracchi (1999).

6 This conclusion is supported by the results of a number of different studies, such as Diamond and Gruber (1999), and Boldrín, Jiménez, and Peracchi (1999).
households’ retirement decision, using computable general equilibrium models. These articles also share the following features: (i) their model economies are populated by heterogeneous agents, and (ii) they study the aggregate and welfare effects of social security reforms.

Sánchez Martín (2003) studies a life cycle model where households are heterogeneous in their education and make endogenous retirement decisions between ages 60 and 64, with age 65 being the mandatory retirement age. However, households are homogeneous within each educational type because their endowments of efficiency labor units are deterministic. He calibrates his model economy to the Spanish economy. With the exception of the retirement behavior of low income workers, his model economy fails to account for the facts that characterize the retirement behavior of Spanish households. Specifically, in his model economy every worker who chooses to retire at age 60 collects the minimum pension. This is because non-high school workers are the only ones who choose to retire at this age and they all collect minimum pensions. This is not the case for high school and college workers for two reasons: because the labor income foregone is higher for more productive types, and because their average labor earnings are higher than the minimum pension. Consequently, these workers have an additional incentive to continue to work in order to avoid the early retirement penalty, and they choose to do so until age 65 (the mandatory retirement age). This has two implications: First, in Sánchez Martín’s model economy the participation rates of non-high school, high school and college workers aged 60 to 64 are 0 percent, 100 percent, and 100 percent respectively. And second, the conditional probabilities of retirement between ages 61 and 64 are zero.7

Fonseca and Sopraseuth (2004) study a life cycle model where households are altruistic and differ in their skills (unskilled to skilled workers). High skilled workers enter to their economy at age 23, and low and medium skilled workers at age 20. Households are also heterogeneous in their labor status. Specifically, they can be employed, unemployed, or retired. However, and as in Sánchez Martín (2003), households are homogeneous in labor income within skill and labor status groups. Fonseca and Sopraseuth calibrate their model economy to both the French and the Italian economies in the year 2000. However, their benchmark model economies fail to account for the retirement behavior of both the French and the Italian households. In their model economy calibrated to the Italian economy, every worker chooses to retire at the first retirement age of 60. In their model economy calibrated to the French economy, low and medium skilled workers also choose to retire at the first retirement age of 60, and the high skilled workers wait until the age of 63. This is for two reasons: First, every worker can claim his or her pension without penalization for early retirement once he or she has contributed for at least 40 years, in the case of France, and 35 years in the case of Italy. And second, even the high skilled workers have labor income levels that are not high enough to give them an incentive to delay retirement.

This brief literature review shows that those model economies which abstract from heterogeneity in labor income within educational/skill groups fail to account for the retirement behavior of older workers. Specifically, probabilities of early retirement depend on the relationship between pension systems’ rules and labor income level, and these probabilities are independent of the individuals’ education.

7 Sánchez Martín’s model economy also fails in accounting for the average retirement age in Spain. Specifically, this statistics is 63.6 in his model economy, but 60.4 in Spain in 1995.

8 See Gruber and Wise (1999) for a description of the retirement behavior of both the French and Italian households.
2.3 Trends in education

The labor force became more educated in most developed countries. For instance, the average years of schooling in the population aged 25-64 has grown 0.8% per year over the past 40 years in the European Union. This number is 0.8% per year for U.S.. Table 3 shows the projections of this variable for some European countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>2002</th>
<th>2012</th>
<th>2052</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>9.6</td>
<td>10.6</td>
<td>11.9</td>
</tr>
<tr>
<td>France</td>
<td>10.9</td>
<td>11.4</td>
<td>12.1</td>
</tr>
<tr>
<td>Germany</td>
<td>12.7</td>
<td>12.8</td>
<td>12.7</td>
</tr>
<tr>
<td>Italy</td>
<td>9.7</td>
<td>10.4</td>
<td>11.1</td>
</tr>
<tr>
<td>UK</td>
<td>12.1</td>
<td>12.4</td>
<td>12.9</td>
</tr>
</tbody>
</table>

Source: Montanino, Przywara, and Young (2004).

As we see in Table 3, Spanish households also became significantly more educated. According to Meseguer (2001) in 1977 around 9 percent of Spanish working age people had high school studies and 3 percent had college studies. Twenty years later, in 1997, these shares were 24 percent and 13 percent. In 2050, according to Meseguer’s projections, they will be 38 percent and 24 percent.

3 The model economy

The model is a production economy in discrete time $t = 1, 2, \ldots$, where a period $t$ corresponds to one year. There are three types of agents: Government, Households, and Firms.

3.1 Government

The government in this model economy plays two roles: it runs a pension system, and it spends and taxes.

The pension system redistributes resources intergenerationally through a pay-as-you-go system, financed with workers’ contributions on gross labor earnings up to a maximum. These contributions are described by the social security tax function, $\tau_s(y_t)$, where $y_t$ denotes gross labor earnings at period $t$. Every household must retire at age 65. However, households may retire after they reach age 60. If they choose to do so, their pensions are penalized by an age-dependent factor $\lambda_j$.

A retiree of age $j$ receives a pension $b(j)$. There is a minimum retirement pension received by all retirees, $b_{\text{min}}$, and a maximum retirement pension, $b_{\text{max}}$. The retirement pension, $b(j)$, is computed according to:

$$b(j) = (1 - \lambda_j) \phi \left[ \frac{1}{N_b} \left\{ \sum_{i=j-N_b}^{j-1} y_i \right\} \right]$$

which combines an average of gross labor earnings during the last $N_b$ years previous to the retirement from the labor force, a replacement rate $\phi$, and the coefficient of penalization for early retirement. The age-dependent penalization takes the value $\lambda_j$.
\[ \lambda_j = \begin{cases} 
> 0 & \text{if } 59 < j < 65 \\
= 0 & \text{if } j = 65 
\end{cases} \]  

(2)

In addition, the pension system provides a disability pension, \( b_d \), for those disabled households. This disability pension is a constant proportion of the minimum retirement pension. Table 4 summarizes the rules of the Retirement Pension System in my model economy.

<table>
<thead>
<tr>
<th>Table 4: The Retirement Pension Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spain</strong></td>
</tr>
<tr>
<td>Payroll Tax</td>
</tr>
<tr>
<td><strong>Regulatory Base</strong></td>
</tr>
<tr>
<td>Replacement Rate</td>
</tr>
<tr>
<td>Penalties for early retirement</td>
</tr>
<tr>
<td>Floor and ceilings</td>
</tr>
</tbody>
</table>

Note: The rules describing the Spanish Public Pension System are those of the Régimen General de la Seguridad Social.

The government collects taxes, \( T_t \), through a proportional consumption tax, \( \tau_{ct} \), a proportional labor income (the net of social security contributions) tax, \( \tau_{lt} \), and a proportional capital income tax, \( \tau_{kt} \). In addition, the government confiscates unintended bequest, \( E_t \). Government also consumes, \( G_t \), an exogenous and constant proportion of output, \( Y_t \), each period. In addition, there exists public debt, \( B_t \), which also represents an exogenous and constant proportion of output each period. Finally, the government makes transfers to households, \( Z_t \), apart from those of the Pension System.

Each period, \( \tau_{ct} \) adjust in order to have equilibrium in the government budget constraint:

\[ G_t + P_t + (1 + r_t)B_t + Z_t = T_t + T_{st} + B_{t+1} + E_t \]  

(3)

where \( T_{st} \) and \( P_t \) are the total contributions and pensions from the pension system.

3.2 Households

3.2.1 Demographics

I assume that my model economy is inhabited by a continuum of heterogeneous households, which differ in their education. Households enter the economy at age 20, and for reasons that will become clear later on, they can live up to a maximum of 100 years. They face a death hazard every period with conditional probability of survival from age \( j \) to \( j + 1 \) at period \( t \) given by \( \psi_{jt} \). Households also have children at the age-specific fertility rate \( f_{jt} \). Let \( \mu_{hjt} \) be the measure of households with education \( h \), age \( j \), at any period \( t \). Hence, period \( t \) population growth rate, \( (1 + n_t) \), is given by:

\[ (1 + n_t) = \sum_{j=20}^{100} f_{jt} \sum_h \mu_{hjt} + \sum_{j=20}^{100} \psi_{jt} \sum_h \mu_{hjt} \]  

(4)
and the measure $\mu_{hjt}$ evolves along time according to:

$$\mu_{hjt+1} = \frac{\psi_{jt}}{(1 + n_t)} \mu_{hjt}$$  \hspace{1cm} (5)$$

$$\mu_{h20t+1} = \frac{1}{(1 + n_t)} \sum_{j=20}^{100} f_{jt} \mu_{hjt}$$  \hspace{1cm} (6)$$

3.2.2 Education

I abstract from the education decision, so education is determined at birth. In addition, I impose that newborns may be endowed with any of three different stocks of human capital. The first possibility is that households have non-high school studies, so $h = 1$. For those households who have completed high school studies, I assign them $h = 2$. Finally, households that have completed college studies are referenced with $h = 3$.

3.2.3 Endowments of efficiency labor units

At any period $t$, workers’ labor productivity has two components: a deterministic labor productivity index $c_{hj}$, and an uninsured idiosyncratic stochastic shock $s$. The stochastic process for labor productivity is independent and identically distributed across households and follows a finite state Markov chain. The conditional transition probability matrix is

$$\Gamma_{ss'} = \Gamma(s'|s) = Pr\{s_{t+1} = s'|s_t = s\}, \text{ where } s \text{ and } s' \in S = \{1, 2, ..., m_s\}.$$

3.2.4 Health

At any period $t$, workers face health risk. Specifically, if a worker with education $h$ and age $j$ survives to the next period, he faces a probability $\varphi_{hj}$ of becoming disabled at the beginning of age $j + 1$. Given that in my model economy, households go through the life cycle stages of working and retirement, their labor status is denoted with the variable $e$. That is, workers are referenced with $e = 1$, disabled households are referenced with $e = 2$, and retirees are left with $e = 3$.

3.2.5 Preferences

I assume that households value both their consumption and leisure. Consequently, the households’ preferences can be described by the following standard expected utility function:

$$E[\sum_{j=20}^{100} \beta^{j-1} u(c_j, (1 - l_j))]$$  \hspace{1cm} (7)$$

where the function $u$ is continuous and strictly concave in both arguments, $\beta$ is the time discount factor, $c_j$ is consumption, and $l_j$ is labor. Consequently, $(1 - l_j)$ is the amount of time that the households allocate to non-market activities.

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9I include within this group illiterate households to those who have compulsory studies. Due to the changes in the Spanish educational laws, I will assume later on that compulsory studies is equivalent to Estudios Secundarios Obligatorios (ESO), Graduado Escolar, Certificado Escolar, and Bachiller Elemental.
3.2.6 The households’ decision problem

In order to state the households’ maximization problem, I split it according to three different stages of their life cycles.

A. From age 20 to age 59 (Households are not allowed to collect a retirement pension during this period)

**Workers**

Within this stage of their life cycles, households make optimal decisions for consumption, savings, and hours worked.

\[
V(h, j, s, 1, a, b) = \max_{c,l,a} \{u(c, (1 - l)) + \beta \psi_j [(1 - \varphi_{hj}) \sum_{s' \in S} \Gamma_{s's'} V(h, j + 1, s', 1, a', b') + \varphi_{hj} V(h, j + 1, s, 2, a', b')] \}
\]

\[
(1 + \tau_c)c + a' = (1 - \tau_l)[y - \tau_s(y)] + (1 + r(1 - \tau_k))a + z
\]

(8)

\[
b' = \begin{cases} 
0 & \text{if } j < 60 - N_b \\
\frac{(b + y)}{(j - (60 - N_b - 1))} & \text{if } 59 - N_b < j < 60 \quad ; \quad a' \geq 0
\end{cases}
\]

where \( c \) denotes the net capital rental rate, \( w \) denotes the wage rate, \( y = wsel \) denotes the gross labor earnings, and \( z \) denotes government transfers. Prime variables denote their end of period values. The law of motion of \( b \) captures the main features of the Spanish social security benefits. That is, the retirement pension is the average of gross labor earnings during the last \( N_b \) years prior to retirement. Given that the first possible retirement age from the labor force is set at the age of 60, I start to compute the pension claims when households are aged \((60 - N_b)\) years.

**Disabled**

Within this stage of their life cycles, disabled households make optimal decisions for consumption and savings.

\[
V(h, j, 2, a, b) = \max_{c,a} \{u(c) + \beta \psi_j V(h, j + 1, 2, a', b') \}
\]

\[
(1 + \tau_c)c + a' = (1 + r(1 - \tau_k))a + b_d + z
\]

(9)

\[
b' = b \quad ; \quad a' \geq 0
\]

Note that these households receive, in addition to government transfers, \( z_t \), the disability pension, \( b_d \).
From age 60 to age 64 (If households choose to collect the retirement pension, they must pay a penalty that reduces their pensions)

Workers

Within this stage, workers must decide if they continue to work. Specifically, they make optimal decisions for the following problems. First, continuing to work implies that they must solve:

$$V(h, j, s, 1, a, b) = \max_{c, l, a'} \{ u(c, (1 - l)) + \beta \psi_j [(1 - \varphi_{hj}) \sum_{s' \in S} \Gamma_{ss'} V(h, j + 1, s', 1, a', b')
+ \varphi_{hj} V(h, j + 1, s, 2, a', b')]\}$$

$$+ (1 + \tau_c) c + a' = (1 - \tau_i) [y - \tau_s(y)] + (1 + r(1 - \tau_k)) a + z$$

$$b' = (b + y)/N_b \quad ; \quad a' \geq 0$$

On the other hand, retiring implies that they must solve the following problem:

$$V(h, j, s, 1, a, b) = \max_{c, a'} \{ u(c) + \beta \psi_j V(h, j + 1, 3, a', b')\}$$

$$+ (1 + \tau_c) c + a' = (1 + r(1 - \tau_k)) a + z + b(j)$$

$$a' \geq 0$$

where $b(j)$ is the retirement pension, net of penalizations. Hence, after solving these problems, workers decide if working or not. That is, they choose the decisions which give them the higher expected lifetime utility.

To understand the impact of pension rules in retirement behavior, let us see the marginal cost and benefits of continuing to work. The costs are basically two: the reduction in leisure, and the foregone pension. The benefits are also two: the collected earnings and the reduction in the early retirement penalization. There is also another effect. This is the change in the pension claim. This change could be either a benefit or a cost, depending it of both worker’s productivity and the pension claim at the moment of the retirement decision.

Minimum retirement pension plays a significant role in the retirement decision. Specifically, the minimum pension eliminates the incentive to reduce the early retirement penalization, since this retirement pension is the minimum amount received by all retirees.
Disabled

Disabled households can also choose to claim the retirement pension. Specifically, at this stage these households are given the option of not receiving any more the disability pension, and collect the retirement pension net of penalizations for early retirement, \( b(j) \). Hence, they must solve the following problems:

\[
V(h, j, 2, a, b) = \max_{c,a'} \{ u(c) + \beta \psi_j V(h, j + 1, 2, a', b') \}
\]

\[
(1 + \tau_c)c + a' = (1 + r(1 - \tau_k))a + z + b_d
\]

\[ a' \geq 0 \tag{12} \]

if they decide to continue collecting the disability pension, \( b_d \). On the other hand, if they choose to collect the retirement pension:

\[
V(h, j, 2, a, b) = \max_{c,a'} \{ u(c) + \beta \psi_j V(h, j + 1, 3, a', b') \}
\]

\[
(1 + \tau_c)c + a' = (1 + r(1 - \tau_k))a + z + b(j)
\]

\[ a' \geq 0 \tag{13} \]

Their retirement pensions are computed as the average gross labor earnings between the age \((60 - N_B)\) and the age in which they became disabled, or it is the minimum retirement pension if they became disabled before age \((60 - N_B)\).

C. From age 65 to age 100 (Every household that reaches age 65 is forced to retire)

In this last stage, households make optimal decisions for consumption and saving

\[
V(h, j, e, a, b) = \max_{c,a'} \{ u(c) + \beta \psi_j V(h, j + 1, e', a', b') \}
\]

\[
(1 + \tau_c)c + a' = (1 + r(1 - \tau_k))a + z + b(j)
\]

\[ if \ j = 65 \ e = \begin{cases} 1 & \text{if } j > 65 \ e = e' = 3 ; \quad b = b' = b(j) ; \quad a' \geq 0 \end{cases} \]

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3.3 Technology

We assume that aggregate output, $Y_t$, depends on aggregate capital, $K_t$, and the aggregate labor input, $L_t$, through a constant return to scale production function, $Y_t = f(K_t, L_t)$. Firms are competitive in the product and factor markets and the profit maximizing behavior gives rise to the following first order conditions:

$$ r_t = F_K(K_t, L_t) - \delta_t \quad (15) $$

$$ w_t = F_L(K_t, L_t) \quad (16) $$

where $\delta$ stands for the capital’s depreciation rate. Note that $Y_t$ grows because the educational transition and the population growth rate.

3.4 Definition of equilibrium

Let $h \in H = \{1, 2, 3\}$, $j \in J = \{20, 21, \ldots, 100\}$, $s \in S = \{1, 2, \ldots, m_s\}$, $e \in E = \{1, 2, 3\}$, $a \in R_+$, and $b \in B = [b_{\min}, b_{\max}]$. Also, let $\chi$ be the probability measure of $\mathcal{R} = H \times J \times S \times E \times R_+ \times B$.

Given initial conditions $K_1$, $B_1$, and $\chi_1$, a competitive equilibrium for this economy is a sequence of household value functions $\{v_t(h, j, s, e, a, b)\}_{t=1}^{\infty}$; sequences of household policies, $\{c_t(h, j, s, e, a, b), l_t(h, j, s, e, a, b), a_t(h, j, s, e, a, b)\}_{t=1}^{\infty}$, sequences of government policy, $\{b_{\min}, b_{\max}, b_{\delta}, \phi, \psi, \tau_{st}(y_t), \lambda_{jt}, \tau_{ct}, \tau_{kt}, G_t, B_t, Z_t\}_{t=1}^{\infty}$, measures of households, $\{\chi_t\}_{t=1}^{\infty}$, vector of factor prices, $\{r_t, w_t\}_{t=1}^{\infty}$, and vector of macroeconomic aggregates, $\{K_t, L_t, T_t, T_{st}, E_t, Z_t, P_t\}_{t=1}^{\infty}$, such that the following conditions hold:

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

$$ K_{t+1} = \int k'_t d\chi_t \quad (17) $$

$$ L_t = \int s\ell_t d\chi_t \quad (18) $$

$$ T_t = \int \tau_{ct}c_t d\chi_t + \int \tau_{kt}l_t a_t d\chi_t + \int \tau_{lt}[y_t - \tau_{st}(y_t)] d\chi_t \quad (19) $$

$$ T_{st} = \int \tau_{st}(y_t) d\chi_t \quad (20) $$

$$ E_{t+1} = \int (1 - \psi_{jt})(1 + r_t)a'_t d\chi_t \quad (21) $$
\[
Z_t = \int z_t d\chi_t
\]  
\[
P_t = \int b_t d\chi_t + b_{dt} d\chi
\]

where all the integrals are defined over the state space \( \mathbb{R} \).

\(\text{(ii) Given, } \chi_t, K_t, L_t, \text{ and the government policy, the household policy solves the household’s decision problem described from (8) to (14), and factor prices are the factor marginal productivities, as described in (15) and (16).}\)

\(\text{(iii) The goods market clears:}\)
\[
\int c_t d\chi_t + K_{t+1} + G_t = F(K_t, L_t) + (1 - \delta) K_t
\]
\(\text{(iv) The government budget constraint is satisfied:}\)
\[
G_t + P_t + (1 + r_t) B_t + Z_t = T_t + T_{st} + B_{t+1} + E_t
\]
\(\text{(v) The law of motion for } \chi_t \text{ is:}\)
\[
\chi_{t+1} = \int \mathbb{R} Q(h, j, s, e, a, b; \mathbb{N}) d\chi_t
\]

where \( Q \) is the transition function, and \( \mathbb{N} \subset \mathbb{R} \)

4 Calibration

To specify this model economy I must choose specific forms for various functions and choose values for their parameters.

4.1 Functional forms and parameters

\textit{Government}

To characterize the Social Security Policy, I must choose the disability pension, \( b_{dt} \), the maximum and minimum retirement pensions, \( b_{max} \) and \( b_{min} \), the age-specific penalization for early retirement, \( \lambda_j \), the replacement rate, \( \phi \), the number of years of contributions used to compute the pension, \( N_b \), and the functional form for the social security tax function.

My choice for the age-specific penalization for early retirement is
\[
\lambda(j) = \begin{cases} 
\lambda_0 + \lambda_1(j - 60) & \text{if } j < 65 \\
0 & \text{if } j = 65 
\end{cases}
\]

The rationale for this choice is because, according to the Spanish \textit{Régimen General de la Seguridad Social}, penalizations for early retirement are a linear function of the retirement age.
Finally, I must choose a model economy’s social security tax function. Remember that workers’ contributions to the Spanish pension system are a fixed proportion of labor earnings up to a maximum. Hence, my choice is:

\[ \tau_s(y_t) = a_0 - [a_0(1 + a_1 y_t)^{-y_t}] \]  

The rationale for this functional form is because this function reaches a maximum \( a_0 \) in the \( R_+ \), with the parameter \( a_1 \) controlling for the slope of the function.

On the other hand, to characterize the Fiscal Policy, I must choose the values for the consumption tax rate, \( \tau_c \), the labor income tax rate, \( \tau_l \), the capital income tax rate, \( \tau_k \), the government consumption, \( G \), the government debt, \( B \), and the government transfers, \( Z_t \). Hence, the government characterization gives me 15 parameters.

**Demographics**

I have to set the conditional survival probabilities, \( \psi_j \), and the population growth rate, \( n_t \). From the INE’s mortality tables, I obtain the conditional survival probabilities in 1998\(^{10} \). Consequently, to characterize the demographics of the model economy, I must choose the values of one parameter: \( n_t \).

**Education**

In the last thirty years, the Spanish households became significantly more educated. Specifically, in 1977 around 3 percent of Spanish working age people had college studies and 9 percent had high school studies. In 1997, these shares were 13.4 percent and 24.0 percent. The projections for 2050 are 24.1 percent and 38.8 percent, according to Meseguer (2001). The educational shares also change in my model economy. I assume that, given initial conditions, the shares \( i_{ht} \) evolve according to the following equation:

\[ i_{ht} = i_{ht-1} + \eta_h \]  

The rationale for this choice is that the series of these shares appear to be roughly linear into Meseguer’s projections. Therefore, I impose linearity for simplicity. This gives me 6 additional parameters: three initial conditions \( i_{h1} \) and three for \( \eta_h \).

**Endowments of efficiency labor units**

I assume that the deterministic profile is given by the following equation:

\[ \epsilon_{hj} = \alpha_{h0} + \alpha_{h1} j + \alpha_{h2} j^2 \]  

The rationale for this choice is that this functional form captures the concavity of the profiles of workers’ productivity over their life cycle.

I also assume that stochastic efficiency labor units \( (s) \) can take three values. The reasons for this choice are two: First, I want to keep the process on \( s \) as parsimonious as possible; And second, I find that with three states, the Gini indexes of income and earnings distributions of

\(^{10}\)The data is available at www.ine.es/inebase/cgi/um?M=%Ft20%2Fp319&0=inebase&N=&L=. 
my model economy account for the Spanish indexes almost exactly. This gives me 21 additional parameters: nine for $\alpha_{h0}$, $\alpha_{h1}$, and $\alpha_{h2}$, three for $s$, and 9 for the transition probability matrix $\Gamma_{ss}$.

**Health**
I assume that, at the age $j$, the conditional probability of becoming disabled at age $j + 1$, is given by:

$$\varphi_{hj} = \rho_0 e^{(j+1)}$$

(31)

The rationale for this choice are twofold. First, the stock of Spanish disabled people increases more than proportionally with age, according to the data available from Boletín de Estadísticas Laborales\textsuperscript{11}. And second, the data also shows that the stock of Spanish disabled households is different across educational types. This gives me five additional parameters.

**Preferences**
My choice for the households’ common utility function is:

$$u(c_j, (1 - l_j)) = \left[ (c_j)\gamma(1 - l_j)^{(1-\gamma)} \right]^{1-\sigma} / (1 - \sigma)$$

(32)

where $\gamma \in (0, 1)$ is the consumption share and $\sigma$ is the coefficient of relative risk aversion. Hence, these two parameters and the discount factor $\beta$ characterize households’ preferences.

**Technology**
I choose a standard Cobb-Douglas aggregate production function. Consequently, technology gives me two additional parameters: the capital share of income, $\theta$, and the depreciation rate, $\delta$.

**Adding up**
My modeling choices and my calibration strategy imply that I must choose the values of a total of 53 parameters to compute the equilibrium of my model economy. Of these 53 parameters, 15 describe the government policy, one describes the demographics, 6 describe the educational shares, 21 describe the endowment of efficiency units, 5 describe health risk, 3 describe household preferences, and the remaining two describe the aggregate technology.

**4.2 Targets**
To choose values for the model parameters, I use 1997 as my calibration target year since I have data from two of my calibration targets, namely the Spanish Lorenz curves of income and earnings distributions, from this year.

**Government**
I start describing my targets for the social security system.

Minimum and maximum retirement pensions: According to Spanish Seguridad Social, in 1997 the Spanish annual minimum retirement pension was 4,026.18 euros. Annual maximum retirement pension was 4.94 times this amount. These numbers correspond to approximately 32

\textsuperscript{11}The data is available at www.mtas.es/estadisticas/BEL/Index.htm.
and 158 percent respectively of Spanish per capita GDP. To replicate these numbers, in my model economy I make $b_{\text{min}} = 0.3\overline{y}$ and $b_{\text{min}} = 1.49\overline{y}$, where $\overline{y}$ denotes per capita output in the model economy. I make these choices because in the Spanish social security, the minimum retirement pension for households with less than 15 years of contributions, is below 30 percent of the Spanish per capita GDP.

*Years of contributions:* I target the number of years of contributions used to compute the pension, $N_b$. According to the Spanish *Régimen General de la Seguridad Social*, the years of contributions used to compute the pension are 15.

*Penalization for early retirement:* I also target the age-dependent penalization for early retirement, and the maximum penalization. According to the Spanish *Régimen General de la Seguridad Social*, the penalization for early retirement is 8 percent per year prior to age 65, and the maximum penalization is 40% which applies to those retiring at the first early retirement age 60. Note that these two targets determine the values for $\lambda_0$ and $\lambda_1$. Specifically, $\lambda_j$ is set according to:

$$
\lambda_j = \begin{cases} 
0.4 - 0.08(j - 60) & \text{if } 59 < j < 65 \\
0 & \text{if } j = 65 
\end{cases}
$$

*(33)*

*Maximum social security contribution:* In 1997 in Spain, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first 23,980 euros. This number correspond to approximately 54 percent of the Spanish per capita GDP. To replicate this number, in my model economy I make $a_0 = 0.54\overline{y}$ in the expression (28).

*Replacement Rate:* I choose $\phi$ in the retirement pension function described in (1) so that, given disability pensions expenditure, the expenditure in total pension benefits in the model economy match the corresponding ones in the Spanish economy. According to the Boletín de Estadísticas Laborales 2001, expenditures in retirement and disability pensions amounted 10.10 percent of GDP in the Spanish economy, in 1997.

*Payroll tax:* I choose $a_1$ in the social security tax function described in expression (28) so that the revenues obtained from this tax instrument in the benchmark model economy match the corresponding social contributions revenues in the Spanish economy. According to the Boletín de Estadísticas Laborales 2001, social contributions amounted 11.10 percent of Spanish GDP, in 1997.

*Disability pension:* I target the disability pension, $b_d$, to be 75 percent of the minimum retirement pension, $b_{\text{min}}$. Hence, I set $b_d = 0.225\overline{y}$. The rationale for this choice is as follows. In the Spanish *Social Security*, there are several kinds of disability pensions, and the amount payed by these pensions are both below or above the minimum retirement pension$^{12}$.

For the fiscal policy, I do the following. My calibration task is to allocate the different Spanish economy tax expenditure items and tax instruments, as reported in Table 5, to the expenditure items and tax instruments of the benchmark model economy.

$^{12}$The different classes of these disability pensions depend on both the level of disability and the number of years of contributions to the Spanish social security.
Table 5: Tax Revenues and Public Expenditures in 1997

<table>
<thead>
<tr>
<th>Revenues</th>
<th>%GDP</th>
<th>Expenditures</th>
<th>%GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Contributions</td>
<td>11.10</td>
<td>Consumption</td>
<td>17.53</td>
</tr>
<tr>
<td>Individual Income Taxes</td>
<td>7.35</td>
<td>Gross Investment</td>
<td>3.07</td>
</tr>
<tr>
<td>Production Taxes</td>
<td>5.42</td>
<td>Pensions</td>
<td>10.10</td>
</tr>
<tr>
<td>Sales and Gross Receipts Taxes</td>
<td>5.03</td>
<td>Debt Services</td>
<td>4.20</td>
</tr>
<tr>
<td>Corporate Profit Taxes</td>
<td>2.75</td>
<td>Other Transfers</td>
<td>5.41</td>
</tr>
<tr>
<td>Estate Taxes</td>
<td>0.36</td>
<td>Other Expenditures</td>
<td>1.40</td>
</tr>
<tr>
<td>Other Taxes</td>
<td>0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Revenues</td>
<td>6.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Revenues</td>
<td>38.62</td>
<td>Total Expenditures</td>
<td>41.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deficit</td>
<td>3.09</td>
</tr>
</tbody>
</table>

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

To this purpose I calibrate the benchmark model economy transfers to households, and government total expenditure so that they account for the other transfers to households (5.41 percent of GDP), and the government total expenditure (41.71 percent of GDP).

Other transfers: I target a value for the model economy’s aggregate transfers to output ratio of \( Z/Y = 5.41 \). This value correspond to the share of Spanish GDP accounted for by all social transfers minus retirement and disability pensions, in 1997.

Public Debt: I target a public debt to output ratio, \( B/Y \), of 66.7 percent. The rationale for this choice is because this is the number reported by Instituto de Estudios Fiscales (2004) for 1997.

Total expenditures: I also target the government total expenditure in the model economy to be 41.71 percent of model economy output. Hence, the difference between this number and the rest of expenditures items, is allocated to the share of government consumption in my model economy.

Since in my model economy I require the government budget to be balanced, I must allocate these expenditures to the government revenues levied by the consumption tax rate, the labor income tax rate, the capital income tax rate, the payroll tax rate, and the confiscated unintended bequest.

Capital income taxes: I choose the proportional capital income tax rate so that it replicates the average taxation on capital income in the Spanish economy. According to Boscá et al. (1999) this number is 18.7%, so I set \( \tau_k = 0.187 \).

Labor income taxes: I choose the proportional labor income tax (net of social security contributions) so that the revenues obtained from this tax instrument in the benchmark model economy match the corresponding ones in the Spanish economy. According to the Spanish Dirección General de Tributos, labor income tax revenues amounted 79.22% of the individual income tax revenues\(^\text{13}\). Since the individual income tax revenues amounted 7.35 percent of

\(^{13}\)The data is available at www.meh.es/Portal/Temas/Impuestos.
GDP in the Spanish economy, I target the share of the labor income tax revenues to be 5.82 percent of GDP.

Consumption taxes: I choose the proportional consumption tax rate, $\tau_c$, so that the government in the model economy balances its budget.

All these choices for government policy give me a total of 15 targets.

Demographics
According to the INE’s mortality tables, the expected lifetime of Spanish households in 1998 was 79.4 years (conditional on being alive at the age of 20). I set the maximum length of life at 100 in order to replicate this expected lifetime. I target the dependency rate of the Spanish population at 1997 to be 26.5%. The rationale for this number is as follows: According to Encuesta Población Activa (EPA), in Spain there were 6,382,809 people aged 65 or over in 1997. For the same year, there were 24,069,372 people aged between 20 and 64. This way I obtain the figure of 26.5%. Note that, given survival probabilities and the maximum length of life, my target for the dependency rate allows me to determine the value for $n_t$. Thus, I have one additional target.

Education
I target the shares of high school and college working age Spanish people in 1997 and their projections for the year 2050. According to Meseguer (2001), 24.0% of workers had high school studies, and 13.4% of workers had college studies. His projection for the year 2050 is 38.8%, and 24.1% respectively. Hence, I have four additional targets.

Endowments of efficiency labor units
I want the deterministic profiles of labor efficiency units in my model economy to approximate the empirical profiles by educational type of Spanish workers in 1997. Hence, I estimate these empirical profiles with quadratic functions. Note that each of these three targets determine the three parameters $\alpha_{h0}$, $\alpha_{h1}$, and $\alpha_{h2}$.

Health
I want my model economy to mimic some features of the health risk faced by Spanish population. According to INE, in 2002 the percentages of households receiving a disability pension with non-high school, high school and college studies, were 80.9 percent, 10.4 percent, and 8.7 percent respectively. Note that these shares determine the value for $\phi_h$ in (31). Moreover, and according to Boletín de Estadísticas Laborales, the 3.72 percent of Spanish households aged 20 to 64 years were receiving a permanent disability pension. To replicate this number I set $\rho_0 = 0.0014$ and $\rho_1 = 0.0382$ in (31). These choices give me a total of four additional targets.

Preferences
I target the share of disposable time allocated to working in the market to be 32.2%. The rationale for this choice is as follows: According to Encuesta sobre el tiempo de trabajo (INE), the average number of hours worked per worker was 1648, in 1996. If I consider discretionary time to be 14 hours a day, this implies that total discretionary time is 5110 hours. This way I obtain the number 32.2%. Next, I choose a value of $\sigma = 2$, as it is standard assumption in

\[\]
the literature. This gives me two additional targets.

**Technology**
I impose the capital income share in Spain in 1997 to be 0.375. The rationale of this choice comes from the findings of Zabalza (1996). Hence, technology gives me one additional target.

**Aggregates**
I want my model economy’s macroeconomic aggregates to replicate the macroeconomic aggregates of the Spanish economy. Hence, I target a capital-output ratio, $K/Y$, of 2.38, and an investment-output ratio, $I/Y$, of 18.80%. The rationale for these choices is as follows: According to BBVA database, the private capital stock in Spain were 631,430 million euros in 1997. According to INE, the Spanish Gross Domestic Product was 265,7922 million euros in 1997. Dividing these two numbers, I obtain 2.38, which is my target value for the capital output ratio.

To calculate the value of my target for $I/Y$, I use data for 1997 from the INE. Specifically, I define investment as the gross private investment. Hence, this leaves me with two targets.

**Spanish Income and Earnings distribution**
I target the two Gini indexes and six selected points of Spanish income and earnings distributions at 1997, as reported by Budría and Díaz-Giménez (2004), in Tables 6 and 7.

<table>
<thead>
<tr>
<th>Table 6: Spanish Income Distribution in 1997 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintiles</td>
</tr>
<tr>
<td>5–10</td>
</tr>
<tr>
<td>1st-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7: Spanish Earnings Distribution in 1997 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quintiles</td>
</tr>
<tr>
<td>5–10</td>
</tr>
<tr>
<td>1st-5</td>
</tr>
</tbody>
</table>

**Normalizations**
I normalize $s(1)=1$. Moreover, and since the transition probability matrix is a Markov matrix, its rows must add up to one. This property imposes three additional normalizations. I normalize the shares of educational types $p_{3h}=1$. Note that this normalization also imposes that $\sum_{h=1}^{3} \eta_{h} = 1$. Finally, I normalize the $\sum_{h=1}^{3} \phi_{h} = 1$. It implies that I have 7 additional targets.

### 4.3 Choices
The values of some of the model parameters are obtained directly because they are uniquely determined by one of my targets. In this fashion, I make $\sigma = 2$ and $\theta = 0.375$. Similarly, the values of the conditional survival probabilities $\psi_{j}$ were obtained from the INE’s mortality tables. Given these survival probabilities together with the maximum length of life, my target

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**Footnote:** The data can be found at [http://w3.grupobbva.com/TLFB/TLFBindex.htm](http://w3.grupobbva.com/TLFB/TLFBindex.htm).
for the dependency rate of the Spanish economy in 1997, determines the population growth rate in my model economy, \( n_t = 0.0104 \). The values for the shares of educational types, \( i_{h1} \) and \( \eta_h \), were set from Meseguer (2001) and (29). With the quadratic approximation to the empirical profiles of labor efficiency units of Spanish workers, I get the values for \( \alpha_{h1}, \alpha_{h2}, \) and \( \alpha_{h3} \) for the three educational types. From the *Régimen General de la Seguridad Social*, I obtain the values for the coefficients \( \lambda_0 \) and \( \lambda_1 \) in the penalization function, and the value \( N_b \). I take from Boscá *et al.* (1999) the value for the capital income tax rate \( \tau_k = 18.7\% \). The values of the parameters \( \phi_h, \rho_0 \) and \( \rho_1 \) in (31) were set from INE. Finally, the normalization of the endowment of efficiency labor units implies that \( s(1) = 1.0 \).

### Table 8: Parameter Values for the Benchmark Model Economy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demography</td>
<td></td>
</tr>
<tr>
<td>Population Growth Rate</td>
<td>( n_t ) 0.0104</td>
</tr>
<tr>
<td>Preferences</td>
<td></td>
</tr>
<tr>
<td>Time Discount Factor</td>
<td>( \beta ) 0.9736</td>
</tr>
<tr>
<td>Consumption Share</td>
<td>( \gamma ) 0.3730</td>
</tr>
<tr>
<td>Relative Risk Aversion</td>
<td>( \sigma ) 2.0000</td>
</tr>
<tr>
<td>Technology</td>
<td></td>
</tr>
<tr>
<td>Labor Share</td>
<td>( \theta ) 0.3750</td>
</tr>
<tr>
<td>Capital Depreciation Rate</td>
<td>( \delta ) 0.0782</td>
</tr>
<tr>
<td>Fiscal Policy</td>
<td></td>
</tr>
<tr>
<td>Government Consumption</td>
<td>( G/Y ) 0.2110</td>
</tr>
<tr>
<td>Government Debt</td>
<td>( B/Y ) 0.6670</td>
</tr>
<tr>
<td>Other Transfers</td>
<td>( Z/Y ) 0.0541</td>
</tr>
<tr>
<td>Labor Tax Rate</td>
<td>( \tau_l ) 0.1124</td>
</tr>
<tr>
<td>Capital Earnings Tax Rate</td>
<td>( \tau_k ) 0.1870</td>
</tr>
<tr>
<td>Consumption Tax Rate</td>
<td>( \tau_c ) 0.2969</td>
</tr>
<tr>
<td>Public Pension System</td>
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</tr>
<tr>
<td>Maximum Contribution</td>
<td>( a_0 ) 1.1002</td>
</tr>
<tr>
<td>Slope Tax Function</td>
<td>( a_1 ) 0.1050</td>
</tr>
<tr>
<td>Replacement Rate</td>
<td>( \phi ) 0.5091</td>
</tr>
<tr>
<td>Number of Years</td>
<td>( N_b ) 15</td>
</tr>
<tr>
<td>Minimum Pension</td>
<td>( b_{\min} ) 0.6107</td>
</tr>
<tr>
<td>Maximum Pension</td>
<td>( b_{\max} ) 3.0146</td>
</tr>
<tr>
<td>Disability Pension</td>
<td>( b_d ) 0.4580</td>
</tr>
<tr>
<td>Maximum Punishment</td>
<td>( \lambda_0 ) 0.4000</td>
</tr>
<tr>
<td>Yearly Punishment</td>
<td>( \lambda_1 ) 0.0800</td>
</tr>
</tbody>
</table>

Following Castaño* et al.* (2004), the values of the remaining 25 parameters are determined solving the system of nonlinear equations obtained from imposing that the relevant statistics of the model economy should be equal to the corresponding targets. Given that
solutions for these systems are not guaranteed not only to exist but also to be unique, I tried many different initial parameter values and sets of weights to find the best calibration\textsuperscript{16}.

5 Simulation strategy

In the last thirty years Spanish demography has changed significantly. According to the INE, between 1957 and 1977, the average number of children born to Spanish women was 2.8. However, since 1978 this rate has shown a decreasing trend, as is shown in the next figure, reaching the minimum value 1.16 in 1998. One of the consequences of this change in fertility rate is that the ratio of people older than 64 to people aged between 20 and 64, which was 26.5 percent in 1997, is projected to lie between 55-60 percent in 2050.

As I said in the introduction, in the last thirty years, the Spanish households have become significantly more educated. Specifically, in 1977 around 3 percent of Spanish working age people had college studies and 9 percent had high school studies. In 1997, these shares were 13.4 percent and 24.0 percent. The projections for 2050 are 24.1 percent and 38.8 percent, according to Meseguer (2001).

In this article I simulate both the demographic and the educational transitions as follows:

A. Demographic Transition

I assume that in my model economy demographic patterns are non-stationary from 1998. This is due to two reasons: First because Spanish demographic transition began in 1978, and second, because households enter into my model economy at age 20. These patterns are characterized as follows:

\textsuperscript{16}Actually I solved a smaller system of 13 equations because my guesses for the values of aggregate physical capital and aggregate labor uniquely determines the values for $a_0, b_d, b_{min}, b_{max}, Z, B, \tau_l$, because the value of $G$ is determined residually from the government total expenditure, the value of $\tau_c$ is determined residually from the government budget constraint, and because the normalization of the matrix $\Gamma_{ss}$ allows me to determine the values of three of the transition probabilities directly.
1. 1998-2025: Recovery of fertility rates $f_{jt}$. The average number of children per woman increases from 1.16 in 1998, and grows at a yearly rate of 3% until 2012, when this rate starts to decline, reaching a level of 1.87 children per woman in year 2025. This number is constant from year 2026 onwards.17

2. 1998-2050: Increase of life expectancy. I make every cohort have a higher conditional survival probability $\psi_{jt}$. This increase is parameterized in such a way that life expectancy goes up from the value observed in 1998 (79.4 years) to 81 in 2050.

3. 2051-2132: Convergence of population dynamics. When life expectancy stabilizes in 2051, the demographic structure of the population will still adjust for 81 more years, through changes in the population growth rate.

B. Educational Transition

Since in 1997, the population structure in Spain was neither stationary in age nor in education dimensions, I start at 1950 and assume that the population structure was stationary. Educational transition starts in 1951. I assume that in my model economy the labor force composition by educational types becomes stationary at 2050, since this is the last year for Meseguer’s projections. Note that this assumption has two implications: First, the measure of households by educational type entering the economy becomes stationary in 2005 because the maximum working period extends for 45 years. And second, the educational transition ends in 2086, because educational shares for the retirees are still changing after 2050.

17The initial values for the age-specific fertility rates were taken from INE.
6 Calibration results

In this section, I report the calibration results, I discuss the reasons that allow me to account for the retirement behavior of Spanish households almost exactly, and I assess my benchmark model economy as a theory of retirement.

The stochastic endowment of efficiency labor units process. — The procedure used to calibrate my model economy identifies the stochastic process on the endowment of efficiency labor units that determines its behavior. Table 9 reports the transition probabilities on the endowment of efficiency labor units of workers that remain as workers one period later. This table shows that the three shocks are not persistent. Specifically, the expected durations of each of these shocks are 1.3, 1.5, and 1.0 years respectively. The table also shows that workers whose current shocks are \( s = 1 \) or \( s = 3 \) are most likely to make a transition to shock \( s = 2 \) than to any other shocks. Likewise, a worker whose current shock is \( s = 2 \) is most likely to make a transition to shock \( s = 1 \) than to any other shocks.

Table 9: Transition Probabilities

<table>
<thead>
<tr>
<th>From ( s )</th>
<th>( s = 1 )</th>
<th>( s = 2 )</th>
<th>( s = 3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s = 1 )</td>
<td>0.2659</td>
<td>0.7111</td>
<td>0.0230</td>
</tr>
<tr>
<td>( s = 2 )</td>
<td>0.6574</td>
<td>0.3411</td>
<td>0.0015</td>
</tr>
<tr>
<td>( s = 3 )</td>
<td>0.0000</td>
<td>0.9999</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Table 10 reports the stochastic endowment of efficiency labor units and the invariant distribution of the above transition matrix. This table shows that most of workers are of type \( s = 1 \) or \( s = 2 \), with few workers of type \( s = 3 \).

Table 10: Stochastic Endowments And Stationary Distribution If Workers

<table>
<thead>
<tr>
<th>( s )</th>
<th>( s = 1 )</th>
<th>( s = 2 )</th>
<th>( s = 3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( s )</td>
<td>1.0000</td>
<td>2.8362</td>
<td>3.1944</td>
</tr>
<tr>
<td>( \pi(s)% )</td>
<td>46.70</td>
<td>52.15</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Public expenditure and tax revenues. — I report selected expenditure items and tax revenues to income ratios in Spain and in the benchmark model economy in columns 3 to 8 of Table 11. I find that these ratios are very similar in both economies.

Macroeconomic aggregates and the allocation of time. — I report the values of my aggregate targets for Spain and for the benchmark model economy in columns 1 and 2 of Table 11, and the share of hours worked\(^{18}\). We see that all these statistics are very similar in both economies.

\(^{18}\) The numerator of column 8 are the taxes raised over the income of production factors. For the Spanish economy, this is the sum of the revenues raised by the \textit{Impuesto sobre la Renta de las Personas Físicas} and the \textit{Impuesto Sobre Sociedades} as reported by INE.
### Table 11: Ratios in 1997

<table>
<thead>
<tr>
<th></th>
<th>$K/Y$</th>
<th>$I/Y$</th>
<th>$INT/Y$</th>
<th>$B/Y$</th>
<th>$Z/Y$</th>
<th>$P/Y$</th>
<th>$T_s/Y$</th>
<th>$(T_k + T_l)/Y$</th>
<th>$h$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>2.38</td>
<td>18.8%</td>
<td>4.2%</td>
<td>66.7%</td>
<td>5.4%</td>
<td>10.1%</td>
<td>11.1%</td>
<td>10.0%</td>
<td>32.2%</td>
</tr>
<tr>
<td>Benchmark</td>
<td>2.37</td>
<td>19.6%</td>
<td>5.2%</td>
<td>66.7%</td>
<td>5.4%</td>
<td>10.1%</td>
<td>10.8%</td>
<td>10.3%</td>
<td>30.5%</td>
</tr>
</tbody>
</table>

**Note:** Variable $h$ (col. 9) denotes the average share of disposable time allocated to the market. The statistic $INT/Y$ (col. 3) is the ratio of the interest payments of public debt to GDP.

**The distribution of income.** — I report the Gini indexes and selected points of the Lorenz curves of income in Spain and in the benchmark model economy in Table 12. I find that my benchmark model economy accounts for the Spanish distribution of income almost exactly. If we look at the fine print, we find that my model economy generates a small higher inequality in the income distribution as indicated by its Gini index.

### Table 12: Households Income Distribution in 1997 (%)

<table>
<thead>
<tr>
<th></th>
<th>Gini</th>
<th>Lowest Groups (%)</th>
<th>Quintiles</th>
<th>Top Groups (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1–5</td>
<td>5–10</td>
<td>1st</td>
</tr>
<tr>
<td>Spain</td>
<td>0.39</td>
<td>0.0</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Benchmark</td>
<td>0.40</td>
<td>0.1</td>
<td>0.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**The distribution of earnings.** — I report the Gini indexes and selected points of the Lorenz curves of earnings in Spain and in the benchmark model economy in Table 13. We see that both distributions are very similar. We find that the main differences are that the shares of earnings earned by the first and fourth quintiles are higher in the model than in the data, and that it is compensated by the shares earned by the third and fifth quintiles.

During my research, I tried many parameterizations increasing the accuracy of these statistics at the expense of the accuracy of other calibration targets, and these changes made little difference to my overall findings.

### Table 13: Households Earnings Distribution in 1997 (%)

<table>
<thead>
<tr>
<th></th>
<th>Gini</th>
<th>Lowest Groups (%)</th>
<th>Quintiles</th>
<th>Top Groups (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1–5</td>
<td>5–10</td>
<td>1st</td>
</tr>
<tr>
<td>Spain</td>
<td>0.57</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Benchmark</td>
<td>0.55</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Average retirement age, employment rate, and minimum retirement pension.** — I report in Table 14 the average retirement age, the employment rate for those households aged 60 to 64, and the percentage of households, who retiring at the age of 60, collects the minimum retirement pension for Spain and my benchmark model economy.\(^{19}\)

### Table 14: Retirement in 1997

<table>
<thead>
<tr>
<th></th>
<th>Spain</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Retirement Age</td>
<td>60.4</td>
<td>59.9</td>
</tr>
<tr>
<td>Employment Rate (60-64 years) (%)</td>
<td>26.0</td>
<td>30.1</td>
</tr>
<tr>
<td>Early Retirees (60) holding $b_{\text{min}}$ (%)</td>
<td>67.7</td>
<td>79.3</td>
</tr>
</tbody>
</table>

--

\(^{19}\)The average retirement age for Spain is for both female and male workers in 1995 (Blöndal and Scarpetta, 1997). The percentage of early retirees holding minimum pension in Spain is the number that Sánchez Martín (2003) reports, and corresponds to the year 1995.

27
Note that my model economy accounts for the average retirement age and the employment rate of those Spanish households aged 60 to 64 almost exactly. Moreover, I find that 79.3 percent of those retiring at the age of 60 collect the minimum retirement pension. Specifically, I find that 82.7% of workers who choose to retire at age 60 are non-high school, and 93.6% of all the non-high school who retire at 60 collect the minimum pension. In addition, 13.0% of the high school workers and 0.4% of college workers, retiring at age 60, collect the minimum pension.

Many disabled households also choose to collect the retirement pension at the age of 60. Specifically, 57 percent of disabled households aged 60 do so. This is because they all apply for the minimum retirement pension. Since the minimum retirement pension is exempt from early retirement penalties, the strong incentives to delay the collection of this benefit associated with these penalties disappear.

I also find that most of the workers who choose to retire at age 60 and do not collect minimum pensions are low income workers. Specifically, these workers have the incentive to retire because: (i) a lower labor earning decreases the cost of leisure, and (ii) if they decide to work, labor earnings are low and hence their pensions would decrease, as current gross labor earnings move into the averaging period and substitute for the value observed 15 years before. It means that their social security wealth would be reduced, despite of the reduction in their early retirement penalizations.

In order to provide the reader with a clearer idea of how the incentive to continue to work changes with the level of labor income, I compute the implicit tax/subsidy of continuing to work for those workers aged 60 to 64 who are not subject to the minimum pension claim.

I do this for both low and high labor income workers who are at the beginning of each age \( j \), in the median of the pension claim distribution. I choose the median of the distribution for two reasons. First, I want to eliminate the effect of the minimum pension on retirement behavior, so choosing the median of the distribution guarantees that even a worker who chooses to retire at age 60, collects a pension, after the early retirement penalization, higher than the minimum pension. And second, because I want to show how the incentives to retire at any age \( j \) can be very different depending on the level of labor income at that age, even for workers with similar previous labor income profiles. The methodology is the following:

A — I denote as high income workers those workers facing the highest labor productivity shock. Then, I compute the implicit tax/subsidy of these workers for every educational type. The final implicit tax/subsidy comes from averaging the implicit tax/subsidy of each educational group by their employment rates at each age between 60 and 64.

B — I denote as low income workers those workers facing the lowest labor productivity shock at every age between 60 and 64. Then, I proceed in the same way as for high income workers, but assuming that the time allocated to labor market activities is 25% of the total endowment. I make this assumption for two reasons. First, because most of these workers choose to retire so their labor supply is zero. And second, because the empirical profile of hours worked by Spanish workers shows that their labor supply at ages 60 to 64 is lower than at age 50. Hence, I choose 25% since this number is around 80% of hours worked by households aged 50 in my model economy.
Table 15 shows the age dependent implicit tax/subsidy.

### Table 15: Implicit tax/subsidy on continuing to work (%) in the benchmark model economy

<table>
<thead>
<tr>
<th>Age</th>
<th>Low income</th>
<th>High income</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>16.7</td>
<td>-30.9</td>
</tr>
<tr>
<td>61</td>
<td>45.7</td>
<td>-26.2</td>
</tr>
<tr>
<td>62</td>
<td>71.1</td>
<td>-22.4</td>
</tr>
<tr>
<td>63</td>
<td>93.0</td>
<td>-18.9</td>
</tr>
<tr>
<td>64</td>
<td>112.0</td>
<td>-16.5</td>
</tr>
</tbody>
</table>

We see that high income workers face a subsidy at every age. This is because two reasons. First, by working one more year, these workers increase their pension claim by 8%, since they reduce the early retirement penalization. And second, the high labor income allows them to increase the pension claim since current gross labor earnings move into the averaging period and substitute for the value observed 15 years before. Finally, note that there is an inverse relationship between subsidy and age. This is due to the concavity in the labor income profile.

For low income workers, there is an increasing age dependent tax on continuing to work. The tax arises because the reduction in the penalization for early retirement is not enough to increase the social security wealth, as low labor income decreases the pension claim. Note that the tax increases with age due to the concavity in the labor income profile. Thus, we see that any low income worker who is not entitled to receive the minimum pension, also has the incentive to retire in order to skip the implicit tax to continue to work.

In conclusion, we see that my model economy generates the two main effects that drive the early retirement behavior of Spanish households. First, the minimum pension which gives strong incentives to leave the labor force at the first retirement age, since this pension eliminates the incentives to keep working in order to reduce the punishment for early retirement. And second, a low level of labor income because it implies a implicit tax on continuing to work. Specifically, the reduction in the penalization for early retirement is not enough for increasing the social security wealth, as the low labor income decreases the pension claim.

**Participation rates by educational groups.** — In Table 16 I report participation rates by educational types for Spain and my benchmark model economy. Notice that they are participation rates and not employment rates. However, it makes little difference, because the percentage of the unemployed people aged 60 to 64 in Spain, was just 2.08% of the total population within this age range in 1997.

### Table 16: Participation rate among individuals aged 60 to 64 by educational level in 1997 (%)

<table>
<thead>
<tr>
<th></th>
<th>Spain</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-High School</td>
<td>25.9</td>
<td>23.4</td>
</tr>
<tr>
<td>High School</td>
<td>38.5</td>
<td>38.4</td>
</tr>
<tr>
<td>College</td>
<td>57.7</td>
<td>55.8</td>
</tr>
</tbody>
</table>

We see that all these percentages are very similar in both economies. Moreover, my benchmark model economy accounts for the relationship between participation and education. That is, the higher the education, the higher the participation rate. This is for two reasons. First
most non-high school workers receive minimum pensions so they choose to retire earlier. And second, while leisure is equally valued across educational types, the foregone labor income is lower for less productive types, who therefore find more convenient to retire early.

**Conditional probabilities of retirement.** — In the next figure, I compare the conditional probabilities of retirement for Spain and my benchmark model economy.  

\[ \text{CONDITIONAL PROBABILITY OF RETIREMENT (\%)} \]

I find that my benchmark model economy can generate the two peaks of the data. Specifically, at the first retirement age 60, the empirical probability is 29.5 percent and in my benchmark model economy this number is 36.0 percent. At the age of 65 the empirical probability is 85.0 percent and in my model economy is 100 percent, since I do not allow households to keep working after this age. Also, my benchmark model economy generates an increasing profile in this variable between ages 61 to 64, just as in the data. These is because the concavity in the labor income profile, which increases (decreases) the implicit tax (subsidy) to continue to work at older ages.

**An assessment.** — I find that my model economy does an extremely good job of accounting for the retirement behavior of Spanish households, and that it improves significantly previous results reported in the literature. Specifically, I find that my model economy generates the two main effects that drive the early retirement behavior of Spanish households. First, the minimum pension which gives strong incentives to leave the labor force at the first retirement age, since this pension eliminates the incentives to keep working in order to reduce the punishment for early retirement. And second, a low level of labor income because it implies a implicit tax on continuing to work. Specifically, the reduction in the penalization for early retirement

\[ ^{20} \text{The empirical data were obtained from Sánchez Martín (2003), and corresponds to the year 1994.} \]
is not enough for increasing the social security wealth, as the low labor income decreases the pension claim. Finally, I am convinced that this class of model economies will soon prove to be very useful to evaluate the aggregate, distributional, retirement, and welfare consequences of social security reforms.

7 Transitions and the pension system

In this section I analyze the consequences of both the demographic and educational transitions on the Spanish Public Pension System. In order to carry out this task, I make the following strategy. I run four different transitions and I compute the pension system deficit in all of them.

A. No transitions. — In the first simulation, I assume that after 1997, there is no demographic transition and the shares of educational types within workers are at their 1997 values. Note that these assumptions have two implications. First, the measure of newborns by educational type is constant from the year 1953, as the maximum working period extends for 45 years. And second, the educational transition ends in 2033 as the educational shares for the retirees are still changing after the year 1997. The results are shown in the next figure.

The results show that the expected deficit of the Spanish Public Pension System is not significative once that we abstract from the demographic transition. This is because the dependency rate is kept constant at its 1997 value, 26.5 percent. Also, the surplus of the Spanish Public Pension System in 1997 turns to a deficit of 0.2 percent of model economy output in the year 2050. This is because there are more retirees with high school and colleges studies in 2050 than in 1997, and these retirees receive higher retirement pensions than non-high school retirees. Hence, the pension expenditure goes from 10.0 percent of model economy output in
1997 to a 11.2 percent of model economy output in 2050.

B. Educational transition. — In this second simulation, I continue to assume that there is no demographic transition after 1997, but I allow a complete educational transition. In other words, educational shares within workers become stationary in 2050, and the educational transition ends in 2086 as the educational shares for the retirees are still changing after year 2050. The results are shown in the next figure.

The results also show that in the year 2050 the Spanish Public Pension System faces a surplus of 0.4 percent. This is because the following. In 2050, in the first simulation (no transitions) there are more non-high school workers within the labor force than in this educational transition. Consequently, less educated workers pay less contributions by 9.5 percent. In the same year, in the first simulation there are more non-high school retirees within retired households than in the educational transition. Consequently, less educated retirees collect lower retirement pensions. However, the pension expenditure is just 3.7 percent lower. This is because the minimum pension. Specifically, most of non-high school retirees receive this minimum pension, and it implies that the reduction in the pension expenditure is smaller than without this minimum scheme.

C. Demographic transition. — The third simulation assumes that after 1997 the shares of educational types within workers are constant at their 1997 values, but I allow the demographic transition. That is, after 1997, age dependent fertility rates change in the way that we impose in section 5. The results are shown in the next figure.
Now, we see from the results a deficit of 10.7 percent of model economy output in the year 2050. This is because the dependency rate increases from 26.5 percent in 1997 to 57.4 percent in 2050.

D. Both transitions. — Finally, I compute the social security deficit in the context of both the demographic and the educational transitions after 1997. The results are shown in the next figure.
We see that the social security deficit as a percentage of the model economy output in the context of both the demographic and educational transitions is 8.7 percent, which is lower than in the context of only the demographic transition for the year 2050. This is because the same reasons as in the first two simulations, A and B. That is, in the demographic transition there are more non-high school workers within the labor force than in this both transitions. Consequently, less educated workers pay less contributions by 10.7 percent. In the same year, in the demographic transition there are more non-high school retirees within retired households than in the both transitions. Consequently, less educated retirees collect lower retirement pensions. However, the pension expenditure is just 2.0 percent lower. This is because the minimum pension. Specifically, most of non-high school retirees receive this minimum pension, and it implies that the reduction in the pension expenditure is smaller than without this minimum scheme.

Finally, note the magnitude of the pension system deficit in the context of both the demographic and the educational transitions: in the year 2050 the model economy predicts that it will be around 8.7 percent of GDP.

8 Reform

In this section I compare the dynamic results under two different policy regimes. In the first regime, rules are kept as they were. In the second regime, government increases the number of years of contributions that are used to compute the pensions, from the last 15 years prior to retirement, to the entire working lifetimes of the agents. This new regime is adopted in 2005, and it only applies to current workers and disabled households. I also assume that one year prior, households did not expect the new social security rules.

8.1 Pensions, retirement, and the pension system

I show the results in the year 2050, concerned with the average pension in the economy and the average retirement age in Table 17.

<table>
<thead>
<tr>
<th>Table 17: Retirement and Average Pension in 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Average Pension</td>
</tr>
<tr>
<td>Average Retirement Age</td>
</tr>
</tbody>
</table>

After the reform, the average pension of the economy decreases by more than 19%. This is due to households being less productive when at a younger age. Specifically, the decrease in the pensions by educational types are the following: 15% for workers with non-high school education, 27% for workers with high school education, and 25% for college workers.

The results for non-high school workers are because they have a flatter life cycle labor income profile, and also because a larger number of households of this type receive the minimum pension.

On the other hand, the results for college workers are due to the fact that for some of them, their average labor income was higher than the maximum pension before the reform. Hence, the maximum pension avoids a bigger drop in their pension claims after the reform.
The reform also changes the retirement behavior of households. This is because after the reform more households are left with the minimum pension, so they find convenient to retire early because minimum pension are exempt of early retirement penalizations. Note the peak in the average retirement age at the year 2045. This is because in that year, the capital to labor ratio reaches the maximum level during the transition. Consequently, the opportunity cost to retire, the wage rate, is also at the maximum level. Finally, note that in both transitions, the average retirement age increases because educational transition leads to bigger shares of households with high school and college studies. They find it more convenient to retire later because the foregone labor income is higher for more productive types.

In Table 18, we report the Social Security Budget.

<table>
<thead>
<tr>
<th></th>
<th>Benchmark</th>
<th>Reform</th>
<th>((R - B))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenues</td>
<td>10.30</td>
<td>10.19</td>
<td>-0.11</td>
</tr>
<tr>
<td>Payments</td>
<td>18.95</td>
<td>15.61</td>
<td>-3.34</td>
</tr>
<tr>
<td>Deficit</td>
<td>8.65</td>
<td>5.42</td>
<td>-3.23</td>
</tr>
</tbody>
</table>

The full impact of the reform operates through these three effects: lower pensions, a lower retirement age, and a different consumption tax rate. As a consequence, the social security deficit decreases from 8.6 to 5.4% of GDP\(^{21}\).

This improvement in the financial condition of the social security system implies that a smaller consumption tax rate is needed to balance the budget, from 40.1% before the reform, to

\(^{21}\)Under the two regimes, the government consumption-output ratio, \(G_t/Y_t\), is kept constant at the value 21.1 percent. However, the public debt-output ratio, \(B_t/Y_t\) is kept constant at 66.7 percent in the first regime. After the reform, I take the sequence \(\{B_t\}_{t=2005}^7\) as given, so because output increases, the ratio \(B/Y\) decreases after the reform.
37.3% after the reform\textsuperscript{22}. However, note that until year 2020, consumption tax rate is higher after the reform. This is because several effects: higher public expenditure in the form of government consumption and transfers to households (both being a fixed proportion of output each period) and a lower tax base for the consumption tax rate, as it is shown in the next subsection.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{consumption_tax.png}
\caption{CONSUMPTION TAX (%)}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{social_security_deficit.png}
\caption{SOCIAL SECURITY DEFICIT (% GDP)}
\end{figure}

\subsection{8.2 Aggregates}

In Table 19 I report the results concerning average variables, factor prices, and selected ratios.

\begin{table}[h]
\centering
\begin{tabular}{lcc}
\hline
 & Benchmark & Reform & \(\Delta\%\) \\
\hline
Y & 2.42 & 2.46 & 1.65 \\
C & 1.53 & 1.49 & -2.62 \\
I & 0.47 & 0.50 & 6.38 \\
K & 6.02 & 6.44 & 6.97 \\
L (effective) & 1.41 & 1.38 & -2.13 \\
K/Y & 2.48 & 2.61 & 5.24 \\
I/Y(\%) & 19.44 & 20.63 & 6.12 \\
r(\%) & 7.28 & 6.49 & -10.86 \\
w & 1.07 & 1.11 & 3.73 \\
h(\%) & 31.59 & 32.45 & 2.74 \\
\(\tau_c(\%)\) & 40.13 & 37.33 & -6.98 \\
\hline
\end{tabular}
\caption{AVERAGE VARIABLES, FACTOR PRICES AND RATIOS IN 2050}
\end{table}

After the reform, the hours worked increase by more than 2 percent, since households demand less leisure. However, labor decreases by more than 2 percent. This is because the consumption tax rate adjusts in order to balance the government budget constraint.

\textsuperscript{22}Remember that the consumption tax rate adjusts in order to balance the government budget constraint.
increase in hours worked cannot compensate the lower average retirement age. The capital stock of the economy is almost 7% higher because the average pension decreases by more than 19%.

Output per capita increases because the higher physical capital compensates the lower effective labor. Finally, consumption decreases. This mainly because two reasons: First, households save more. And second, the lower consumption tax rate cannot compensate the lower pensions.
8.3 Inequality

In Tables 20, 21, and 22 I report the distributions of income, earnings, and wealth respectively.

Table 20: Households Income Distribution in 2050 (%)

<table>
<thead>
<tr>
<th>Gini</th>
<th>1</th>
<th>1–5</th>
<th>5–10</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>10–5</th>
<th>5–1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.42</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>4.7</td>
<td>9.8</td>
<td>14.8</td>
<td>23.2</td>
<td>47.5</td>
<td>11.4</td>
<td>14.2</td>
</tr>
<tr>
<td>Reform</td>
<td>0.43</td>
<td>0.1</td>
<td>0.6</td>
<td>1.1</td>
<td>5.0</td>
<td>9.6</td>
<td>13.8</td>
<td>22.5</td>
<td>49.1</td>
<td>12.0</td>
<td>15.2</td>
</tr>
</tbody>
</table>

As it is shown, there is a small increase in income inequality. This is because there is no significant variation in earnings distribution, and a small increase in wealth inequality, as it is shown in Tables 21 and 22.

Table 21: Households Earnings Distribution in 2050 (%)

<table>
<thead>
<tr>
<th>Gini</th>
<th>1</th>
<th>1–5</th>
<th>5–10</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>10–5</th>
<th>5–1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.57</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>1.0</td>
<td>2.4</td>
<td>12.6</td>
<td>27.6</td>
<td>56.4</td>
<td>15.3</td>
<td>15.5</td>
</tr>
<tr>
<td>Reform</td>
<td>0.57</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.8</td>
<td>2.5</td>
<td>13.1</td>
<td>27.0</td>
<td>56.6</td>
<td>15.7</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Earnings distribution does not change. This is the result of two different effects: First, workers translate hours worked from older to younger ages. Hence, earnings inequality should decrease, as the difference in productivity levels by educational groups are smaller at younger ages. And second, high school and college workers increase hours worked more than non-high school workers, as they face the bigger drops in their retirement pensions.

Table 22: Households Wealth Distribution in 2050 (%)

<table>
<thead>
<tr>
<th>Gini</th>
<th>1</th>
<th>1–5</th>
<th>5–10</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>10–5</th>
<th>5–1</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>0.51</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
<td>6.3</td>
<td>14.9</td>
<td>26.3</td>
<td>51.7</td>
<td>13.1</td>
<td>13.6</td>
</tr>
<tr>
<td>Reform</td>
<td>0.52</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.7</td>
<td>5.9</td>
<td>14.8</td>
<td>26.4</td>
<td>52.2</td>
<td>13.3</td>
<td>13.8</td>
</tr>
</tbody>
</table>

On the other hand, wealth inequality increases because the most productive workers save more, since they face the bigger drops in their retirement pension claims.

8.4 Welfare

In order to quantify the welfare effects of the reform, I will use consumption equivalent variation measure, \( EV \). I quantify the welfare change for every household alive at the moment of the reform by asking by how much this individual’s consumption has to be increased in all future periods and contingencies before the reform, so that his expected utility equals that under the new public pension rules. In other words, I compute:

\[
EV_h = \left( \frac{V_R(h,j,s,c,b',a)}{V_B(h,j,s,c,b,a)} \right)^{-\frac{1}{(1-\sigma)}}, \tag{34}
\]

38
where $b'$ is the pension claim after the reform, and $V_B()$ and $V_R()$ stand for the value functions before the reform and after the reform, respectively. For example, an $EV_h$ of 0.05 implies that if the policy reform is put into place, then an individual with education $h$, will experience an increase in welfare due to the reform, equivalent to receiving 5% higher consumption before the reform in all the possible nodes of his remaining lifetime.

Most of the households alive at the moment of the reform face a negative wealth effect, because the drop in their retirement pensions (claims), and also because they have to pay higher consumption tax rates until year 2020. Hence, the reform implies a welfare loss for the population of 2.53%. This loss is distributed in the following way. All the retirees at the moment of the reform are worse off because they receive the same pension, they have to pay higher consumption tax rates in the next 15 years, and also they receive a lower rent of capital.

Workers are also worse off after the reform. This is because the decrease in their retirement pension claims cannot be compensated by the lower consumption tax rate in the long run. The biggest losses are for those who face the biggest pension drops at the moment of the reform, namely the college workers. Note that after age 60, the losses are very significative, because the high drops in their pension claims and the higher consumption tax rates in the next years. In addition, most of the workers aged 60 to 54 are high productive workers, so the reform implies for them a reduction in the implicit subsidy to continuing to work, since the averaging period for the pension benefit is increased to their entire working lifetime. Note that after age 62, the losses for high school workers are smaller.
Most of disabled households are better off until age 45. This is because until this age, the old rules assigned them the minimum retirement pension, as the retirement pension claims started to be computed since age 46. However, and after the reform, their pension claims are higher, since now they are computed as the average of their labor earnings before these households became disabled. Note that these gains are reduced after age 45. Also, there are big losses after age 60. This is because all households that continue to receive the disability pension at these ages, are those who had high retirement pension claims before the reform, so they were waiting until age 65 in order to skip the penalizations for early retirement. However, after the reform, their retirement pension claims are also reduced.

9 Conclusions

In this article, I construct an overlapping generations model which combines various features of model economies described elsewhere in the literature, and I calibrate it to the Spanish economy. I find that my model economy replicates the basic facts of the retirement behavior of Spanish households, and many of the aggregate and distributional features of the Spanish economy.

I then use my model economy to evaluate the aggregate, distributional, retirement, and welfare consequences of increasing the number of years of contributions that are used to compute the pensions. I find that the reform improves the financial viability of the public pension system through lower benefits, and that it leads to an increase in the capital stock, and output. However, the reform decreases consumption. The reform also brings about welfare losses for the households that are alive when it is adopted. Finally, I find that the reform does not changes income and earnings inequality.

The reform changes the average value of pensions, and it also changes the retirement behavior of households. This is because after the reform more households are left with the minimum pension, and this minimum benefit plays a very significant role in the retirement decision. Specifically, under the current system every worker is entitled to receive the minimum
pension regardless of the number of years during which he has contributed to the system. Moreover, since minimum pensions are exempt from early retirement penalties, the strong incentives to work associated with these penalties disappear. Consequently, every worker who is only entitled to a minimum pension chooses to retire at age 60 (the earliest possible retirement age) both in the benchmark and in the reformed economies.

In future research I intend to use the model described in this article to study other parametric reforms and a fundamental reform that would substitute the current pay-as-you-go pension system with a fully funded system based on mandatory savings.
10 References


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