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**Early Retirement, Social Security, and  
Output Gap**

Julián Díaz Saavedra

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# EARLY RETIREMENT, SOCIAL SECURITY, AND OUTPUT GAP\*

Julián Díaz Saavedra

Universidad de Granada

julianalbertodiaz@ugr.es

## Abstract

We analyze two social security reforms aimed at increasing working lifetimes. The first reform eliminates early retirement provisions, while the second increases both the age of early eligibility and the normal retirement age. We find that although both reforms increase the participation rates of older workers, the elimination of early retirement provisions reduces future social security imbalances if benefits taken early are not reduced actuarially. Additionally, we find that both reforms increase aggregate hours and output, although efficiency gains derived from the elimination of the early retirement scheme are distant from previous estimates since labor supply could be less responsive. Finally, we also find that the output gap brought about by the early retirement scheme may decrease in coming decades.

Keywords: Computable general equilibrium, social security reforms, macroeconomic effects, retirement  
JEL classification: C68, H55, J11, J26

## 1 Introduction

To cope with projected social security budgetary imbalances brought about by the aging of populations, a large number of countries have increased both the age of early eligibility and the normal retirement age - the age at which full social security benefits can be collected. At the same time, however, countries are also reluctant to eliminate early retirement provisions. This is so despite claims that the trend to retire early exacerbates both the fiscal challenge on the budget of social security systems and also the lost output. At most, some countries, such as Germany, Italy, and Spain, have tightened the eligibility requirements for early retirement<sup>1</sup>.

This paper shows that raising both legal retirement ages while maintaining early retirement may be a correct strategy for increasing working lifetimes. Specifically, the paper shows that such a strategy can be rationalized

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<sup>1</sup>Apart from considering that early claimants are particularly vulnerable due to poor health, lack of a private pension, and a physically demanding job, there are several reasons for maintaining early retirement schemes. For instance, Gruber and Wise (1999) suggested that early retirement schemes could be thought to encourage elderly people to withdraw from the labor force in order to provide more job opportunities for young workers. Burtless and Quinn (2002) affirmed that politicians could even be reluctant to increase the age of early eligibility because early retirees would apply for disability insurance and this would imply rising social security administrative costs as eligibility is much more expensive to determine in disability insurance programs, and that some workers who are denied disability insurance would face serious hardship. Finally, and from a political viewpoint, Conde-Ruiz and Galasso (2003) suggested that population aging tends to enhance more support for early retirement schemes by increasing the political power of the elderly.

as policymakers are concerned not only about increasing the working lifetime, but also social security solvency and efficiency, and when benefits taken before the normal retirement age are reduced actuarially. This is because eliminating early retirement schemes does not reduce social security expenditures, and the efficiency gains brought about by this reform could be small and distant from previous estimates. However, when there is little or no actuarial reduction in benefits taken early, the removal of the early retirement scheme should be the preferred instrument of policymakers to raise the labor force participation of older workers as it leads to larger reductions in the fiscal burden on the social security system as well as larger increases in the nation's output.

We use a quantitative model economy to evaluate the consequences of counterfactual experiments on social security reform. Our quantitative experiments rely on the Spanish economy. Some dimensions of the Spanish social security system differ from the US system, and tend to encourage earlier retirement than in the US. For instance, the Spanish system provides a minimum guaranteed benefit which is higher than in the US. Moreover, workers can claim this minimum benefit at the early retirement age. Then, because working an additional year does not increase this minimum amount, the best strategy for some workers - especially those who are less productive - is to leave the labor force as soon as this benefit is first available. Consequently, the participation rates of older workers are higher in the US than in Spain. In the US, for instance, the participation rate for the 60 to 64 age group was 54.5 percent in 2011, while in Spain this rate was 37.7 percent that same year<sup>2</sup>.

Our quantitative model economy of labor supply and retirement decisions gives rise to equilibrium allocations in which workers choose what fraction of their life to devote to employment, and what fraction of their period time endowment to devote to work while employed. This model economy builds on Díaz-Saavedra (2012) and is an enhanced version of the model in Díaz-Giménez and Díaz-Saavedra (2009). Like them, we focus our modeling choices on the importance of the key economic and institutional forces that lead to retirement. Unlike them, this new version approximates the Spanish fiscal instruments more closely since it introduces a progressive tax code on personal income. Including a progressive tax code is important because it may affect the retirement decision, especially for older workers who are in the higher portion of the earnings distribution. Put differently, meaningful evaluations of the retirement consequences of social security reforms require realistic retirement distributions, and this realism should be achieved through the appropriate margins. Consequently, our model economy is able to replicate the empirical age profiles for retirement hazards of older workers and their participation rates across educational groups.

We analyze the transitional dynamics triggered by two counterfactual experiments. In our first experiment, we simulate a reform that eliminates early retirement provisions from 2013 onwards, so that the age of early eligibility and the normal retirement age become the same. In the second experiment, we increase both the age of early eligibility and the normal retirement age by two additional years for that same year, specifically from 60 and 65 years of age to 62 and 67 years of age, respectively. The findings are that these reforms increase the average retirement age, showing that the gains in terms of old-age workers' participation rates are non-trivial. For instance, our quantitative experiments predict that the participation rates of those aged 60 to 70 years old will increase by 4 and 12 percent, respectively. However, we also find that removing the early retirement scheme, and despite that it affects the timing of some workers' retirements, does not save social security money. On the contrary, raising both the age of early eligibility and the normal retirement age significantly improves the social security budget. This is because the first reform increases social security benefits, since benefits taken early are reduced actuarially; a feature of the Spanish social security system shared by other retirement systems such as those of the US and Canada.

In many other European countries, however, there is little or no actuarial reduction over benefits that are taken early. In Germany, for instance, a permanent reduction of 3.6 percent is applied to social security benefits for each year of early retirement before the normal retirement age of 65. To account for this fact, we also study both previous reforms in a model economy where there is little actuarial reduction. This time, we find that the abolition of early retirement provisions increases the long-run participation rates of those aged

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<sup>2</sup>According to Erosa et al. (2011), another reason for this difference in participation rates among the elderly is that high earners in Spain face higher marginal tax rates than their US counterparts.

60 to 70 by an outstanding 24 percent and also significantly reduces the long-run social security imbalance. On the other hand, the findings concerning the second reform are quite similar. Thus, some reforms may succeed in changing retirement patterns, but they may not affect the social security budget<sup>3</sup>. This is the case when lifetime benefits, particularly those available to early claimants, are designed to be approximately equal regardless of the age when they are first collected. Consequently, these results qualify the view that if there is a problem in financing social security, it arises not only from population aging but also from the trend to retire early<sup>4</sup>.

The higher participation rates of older workers increase both aggregate hours and output. Specifically, in the model economy where early benefits are reduced actuarially, the above reforms increase long-run aggregate hours of work by 1.1 and 3.1 percent, with 0.4 and 3.1 percent increases in long-run output. On the other hand, and when we assume little actuarial reduction in early benefits, the numbers arising from the second reformed economy are quite similar, but the abolition of the early retirement scheme increases long-run aggregate hours by 5.8 percent and output by 4.1 percent. Note that the efficiency gains derived from the removal of early retirement provisions that we obtain are distant from previous estimates. For instance, Herbertsson and Orszag (2003) found that early retirement can be held responsible for a 9.3 and 11.1 percent reduction in the potential Spanish annual GDP in 2000 and 2010, with even larger numbers for other European countries. However, what we find is that total labor supply could be less responsive to this type of reform, since older workers supply less hours of work in comparison to their younger counterparts, as indicated by the decline in the profile of working hours late in the life cycle. In addition, work hours may be reallocated over the life cycle, since middle-aged workers could work less, knowing that they will work until an older age and will receive higher social security benefits<sup>5</sup>.

Finally, our results predict that the output gap may decrease in coming years. It is usually assumed that the output lost due to early retirement schemes will increase because there will be more older workers as the population ages. However, the world labor force is gradually becoming more educated. This trend may affect retirement patterns since more educated workers may retire at a later age despite the fact that they value leisure to the same extent as less educated workers. This is due to the fact that the foregone labor income is higher for more productive individuals, who therefore find it more convenient to retire later. Consequently, the average retirement age could increase in coming decades due to the delay time of voluntary retirement of workers. For instance, and for the case of Spain, our model economy predicts that the average retirement age will increase from 63.7 years in 2010 to 65.0 years in 2050 due to the change in the educational composition of the Spanish population.

Our paper belongs to the literature that uses large-scale, discrete time overlapping generations models as pioneered by Auerbach and Kotlikoff (1987) to analyze social security reforms. Since then, and despite several modeling advances, most papers have made claiming social security benefits exogenous. This assumption is not suitable because any social security reform that changes the marginal utility of working will affect the average retirement age and the reported results. The papers by Díaz-Giménez and Díaz-Saavedra (2009) and İmrohoroğlu and Kitao (2012) are two recent exceptions. Díaz-Giménez and Díaz-Saavedra (2009) studied the effects of a three-year increase in the age of early eligibility and the normal retirement age in Spain in a computable general equilibrium model economy where labor supply is endogenous in both the intensive and extensive margins. They found that this reform significantly improves the long-run sustainability of social security. İmrohoroğlu and Kitao (2012) used a quantitative model calibrated to the US economy to study the effects of two social security reforms aimed at increasing the average retirement age. The reforms increase the age of early eligibility or the normal retirement age by two additional years. However, İmrohoroğlu and Kitao (2012) performed their analysis through steady state comparisons under the projected

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<sup>3</sup>Our results are partly related to those of Díaz-Saavedra (2012) and İmrohoroğlu and Kitao (2012). Díaz-Saavedra (2012) studied the consequences of eliminating labor income and payroll taxes for Spanish workers aged 60 to 64 years. He found that this reform increases the participation rate of this age group by 3.8 percentage points, although the social security budget remains essentially the same. İmrohoroğlu and Kitao (2012) analyzed a US social security reform in which the age of early eligibility is raised by two years and obtained similar results.

<sup>4</sup>See, for example, Pestieau (2003), Duval (2004), Conde-Ruiz et al. (2004), and Díaz-Giménez and Díaz-Saavedra (2009).

<sup>5</sup>These results are related to those of French and Jones (2010), and Díaz-Saavedra (2012), and they are also consistent with the findings of McGrattan and Rogerson (1998), who reported that in the last century, US workers shortened their working period and shifted work hours from older to younger ages as social security coverage increased.

US demographics for 2080, and they only analyzed the effects of these reforms on allocations and the solvency of the social security system. In this paper, in contrast, we analyze the transitional dynamics triggered by the social security reforms. Moreover, the calibrated process of stochastic labor income allows the model to replicate the earnings and income distributions of the Spanish economy, so we can study the inequality consequences of social security reforms. These advantages, however, must be set against some disadvantages. In Imrohoroglu and Kitao’s model, agents face medical expenditure and health risk so that their model can capture the fact that unhealthy individuals retire earlier due to their reduced life expectancy. Moreover, their model economy also allows for endogenous decisions on labor force participation, so that they can study how these decisions affect the impact of social security reforms through the adjustment on this margin.

The rest of the paper is organized as follows. Section 2 presents the model economy. Section 3 describes the calibration procedure. Section 4 presents the calibration results. Section 5 describes in great detail the counterfactual experiments. Section 6 describes the demographic, educational, and growth scenarios shared by the benchmark and the reformed model economies. Section 7 presents the results of our quantitative exercises, and Section 8 discuss the robustness of our results. Section 9 concludes.

## 2 The Model Economy

Our model economy, which resembles the model described in Díaz-Saavedra (2012), is an overlapping generations model economy. We assume that it is populated by a continuum of heterogeneous households, a representative firm, and a government. We describe these three sectors below.

### 2.1 Population and Endowment Dynamics

We assume that the households in our model economy differ in their age,  $j \in J$ ; in their education,  $h \in H$ ; in their employment status,  $e \in \mathcal{E}$ ; in their assets,  $a \in A$ ; in their pension rights,  $b_t \in B_t$ , and in their pensions  $p_t \in P_t$ .<sup>6</sup> Sets  $J$ ,  $H$ ,  $\mathcal{E}$ ,  $A$ ,  $B_t$ , and  $P_t$  are all finite sets which we describe below. We use  $\mu_{j,h,e,a,b,p,t}$  to denote the measure of households of type  $(j, h, e, a, b, p)$  at period  $t$ . For convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript.

*Age.* Every household enters the economy when it is 20 years old and it is forced to exit the economy at age 100. Consequently,  $J = \{20, 21, \dots, 100\}$ . We also assume that each period every household faces a conditional probability of surviving from age  $j$  to age  $j+1$ , which we denote by  $\psi_{jt}$ . This probability depends on the age of the household and it varies with time, but it does not depend on the household’s education.

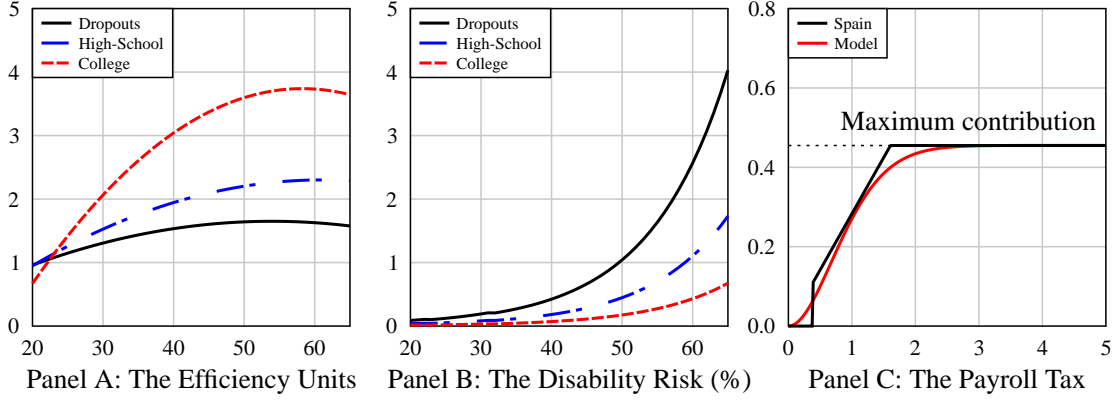
*Education.* We abstract from the education decision, and we assume that the education of every household is determined forever when they enter the economy. We consider three educational levels and, therefore,  $H = \{1, 2, 3\}$ . Educational level  $h=1$  denotes that the household has dropped out of high school;<sup>7</sup> educational level  $h=2$  denotes that the household has completed high school but has not completed college; and educational level  $h=3$  denotes that the household has completed college.

*Population Dynamics.* In the real world the age distribution of the population changes because of changes in fertility, survival rates, and migratory flows. The population dynamics in our model economy are exogenous and we describe them in Appendix 1 below.

<sup>6</sup>To calibrate our model economy, we use data per person older than 20. Therefore our model economy households are really individual people.

<sup>7</sup>In this group we include every household that has not completed the compulsory education. Due to the changes in the Spanish educational laws, we define the compulsory studies to be either the Estudios Secundarios Obligatorios, the Graduado Escolar, the Certificado Escolar, or the Bachiller Elemental.

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



\* The horizontal axis measures labor income as a proportion of Spanish GDP per person who was 20 or older. The vertical axis measures payroll taxes as a proportion of that same variable.

*Employment status.* Households in our economy are either workers, retirees, or disabled households. We denote workers by  $\omega$ , retirees by  $\rho$ , and disabled households by  $d$ . Consequently,  $\mathcal{E} = \{\omega, \rho, d\}$ . Every household enters the economy as a worker. The workers face a positive probability of becoming disabled at the end of each period of their working lives. And they decide whether to retire at the beginning of each period once they have reached the first retirement age, which we denote by  $R_0$ . In our model economy, both the disability shock and the retirement decision are irreversible and there is no mandatory retirement age.

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

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

$$\epsilon_{jh} = a_{1h} + a_{2h}j - a_{3h}j^2 \quad (1)$$

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

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

$$\Gamma[s' | s] = \Pr\{s_{t+1} = s' | s_t = s\}, \text{ where } s, s' \in \omega = \{s_1, s_1, \dots, s_n\}. \quad (2)$$

We assume that the process on  $s$  takes three values and, consequently, that  $s \in \omega = \{s_1, s_2, s_3\}$ . We make this assumption because it turns out that three states are sufficient to account for the Lorenz curves of the Spanish distributions of income and labor earnings in sufficient detail, and because we want to keep this process as parsimonious as possible.

*Retirees.* As we have already mentioned, workers who are  $R_0$  years old or older decide whether remain in the labor force, or whether to retire and start collecting their retirement pension. They make this decision

after they observe their endowment of efficiency labor units for the period. In our model economy retirement pensions are incompatible with labor earnings and, consequently, retirees receive no endowment of efficiency labor units.

*Disabled households.* We assume that workers of education level  $h$  and age  $j$  face a probability  $\varphi_{jh}$  of becoming disabled from age  $j + 1$  onwards. The workers find out whether they have become disabled at the end of the period, once they have made their labor and consumption decisions. When a worker becomes disabled, she exits the labor market and it receives no further endowments of efficiency labor units, but she is entitled to receive a disability pension until she dies.

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

$$q_j = a_4 e^{(a_5 \times j)} \quad (3)$$

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

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

$$\begin{cases} q_j \mu_{j,2007} &= \sum_h \varphi_{jh} \mu_{jh,2007} \\ \varphi_{j2} &= a_6 \varphi_{j1} \\ \varphi_{j3} &= a_7 \varphi_{j1} \end{cases} \quad (4)$$

This procedure allows us to make the disability process dependent on the educational level as is the case in Spain. We represent our calibrated values for  $\varphi_{jh}$  in Panel B of Figure 1.<sup>8</sup>

## 2.2 Preferences

We assume that households derive utility from consumption,  $c_{jht} \geq 0$ , and from non-market uses of their time and that their preferences can be described by the following standard Cobb-Douglas expected utility function:

$$\max E \left\{ \sum_{j=20}^{100} \beta^{j-20} \psi_{jt} [c_{jht}^\alpha (1 - l_{jht})^{(1-\alpha)}]^{(1-\sigma)} / 1 - \sigma \right\} \quad (5)$$

where  $0 < \beta$  is the time-discount factor; 1 is the normalized endowment of productive time; and  $0 \leq l_{jht} \leq 1$  is labor. Consequently,  $1 - l_{jht}$  is the amount of time that the households allocate to non-market activities.

## 2.3 Technology

We assume that aggregate output,  $Y_t$ , depends on aggregate capital,  $K_t$ , and on the aggregate labor input,  $L_t$ , through a constant returns to scale aggregate production function,  $Y_t = f(K_t, A_t L_t)$ , where  $A_t$  denotes an exogenous labor-augmenting productivity factor whose law of motion is  $A_{t+1} = (1 + \gamma_t) A_t$ , and where  $A_0 > 0$ . We choose a standard Cobb-Douglas aggregate production function with capital share  $\theta$ . Aggregate capital is obtained aggregating the capital stock owned by every household, and the aggregate labor input is obtained aggregating the efficiency labor units supplied by every household. We assume that capital depreciates geometrically at a constant rate,  $\delta$ , and we use  $r$  and  $w$  to denote the prices of capital and of the efficiency units of labor before all taxes.

<sup>8</sup>The data on disability can be found at [www.empleo.gob.es/es/estadisticas](http://www.empleo.gob.es/es/estadisticas).

## 2.4 Government Policy

The government in our model economy taxes capital income, household income and consumption, and it confiscates unintentional bequests. It uses its revenues to consume, and to make transfers other than pensions. In addition, the government runs a pay-as-you-go pension system.

In this model economy the government constraint is

$$G_t + Z_t = T_{at} + T_{yt} + T_{ct} + E_t \quad (6)$$

where  $G_t$  denotes government consumption,  $Z_t$  denotes government transfers other than pensions,  $T_{at}$ ,  $T_{yt}$ , and  $T_{ct}$ , denote the revenues collected by the asset income tax, the household income tax, and the consumption tax, and  $E_t$  denotes unintentional bequests. We assume that  $Z$  is thrown to the sea so that they create no distortions in the household decisions.

### 2.4.1 Taxes

Asset income taxes are described by the function

$$\tau_a(y_t^a) = a_8 y_t^a \quad (7)$$

where  $y_t^a$  denotes the income that the households obtain from all their assets.

Household income taxes are described by the function

$$\tau_y(y_t^b) = a_9 \left\{ y_t^b - [a_{10} + (y_t^b)^{-a_{11}}]^{-1/a_{11}} \right\} \quad (8)$$

where the tax base is

$$y_t^b = y_t^a + y_t^l + p_t - \tau_a(y_t^a) - \tau_s(y_t^l) \quad (9)$$

where  $y_t^l$  is labor income, before taxes, at period  $t$ , and  $\tau_s(y_t^l)$  are payroll taxes that same period. Expression (8) is the function chosen by Gouveia and Strauss (1994) to model effective personal income taxes in the United States, and it is also the functional form chosen by Calonge and Conesa (2003) to model effective personal income taxes in Spain.

Consumption taxes are described by the function

$$\tau_c(c_t) = a_{12t} c_t. \quad (10)$$

Finally, we assume that at the end of each period, once they have made their labor and consumption decisions, a share  $(1 - \psi_{jt})$  of all households of age  $j$  die and that their assets are confiscated by the government.

### 2.4.2 The Pension System

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

$$\tau_s(y_t^l) = \begin{cases} a_{13} \bar{y}_t - \left[ a_{13} \bar{y}_t \left( 1 + \frac{a_{14} y_t^l}{a_{13} \bar{y}_t} \right)^{-y_t^l / a_{13} \bar{y}_t} \right] & \text{if } j < R_1 \\ 0 & \text{otherwise} \end{cases} \quad (11)$$



where parameter  $a_{13}$  is the cap of the payroll tax, and  $\bar{y}_t$  is per capita output *at market prices* at period  $t$ . This function allows us to replicate the Spanish payroll tax cap, but it does not allow us to replicate the tax exempt minimum. In Panel C of Figure 1 we represent the payroll tax function for our calibrated values of  $a_{13}$  and  $a_{14}$ .

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

$$p_t = \phi(1.03)^v(1 - \lambda_j) \left[ \frac{1}{N_b} \sum_{t=j-N_b}^{j-1} \min\{a_{15}\bar{y}_t, y_t^l\} \right] \quad (12)$$

where the last expression on the right hand side is called *Regulatory Base*. In this expression 12, parameter  $N_b$  denotes the number of consecutive years immediately before retirement that are used to compute the retirement pensions; parameter  $0 < \phi \leq 1$  denotes the pension system replacement rate; variable  $v$  denotes the number of years that the worker remains in the labor force after reaching the normal retirement age;<sup>9</sup> function  $0 \leq \lambda_j < 1$  is the penalty paid for early retirement; and  $a_{15}\bar{y}_t$  is the maximum covered earnings.

Pensions in our model economy are computed upon retirement and their real value remains unchanged. We also model minimum and maximum retirement pensions. Formally, we require that  $p_{0t} \leq p_t \leq p_{mt}$ , where  $p_{0t}$  denotes the minimum pension and  $p_{mt}$  denotes the maximum pension. We update the minimum pension so that it remains a constant proportion of output per capita.<sup>10</sup>

The Spanish *Régimen General de la Seguridad Social*<sup>11</sup> establishes that the penalties for early retirement are a linear function of the retirement age. To replicate this rule, our choice for the early retirement penalty function is the following

$$\lambda_j = \begin{cases} a_{16} - a_{17}(j - R_0) & \text{if } j < R_1 \\ 0 & \text{if } j \geq R_1 \end{cases} \quad (13)$$

Finally, the Spanish pension replacement rate is a function of the number of years of contributions. In our model economy we abstract from this feature because it requires an additional state variable. It turns out that this last assumption is not very important because, in our our model economy, 99.99 of all workers aged 20-60 in our benchmark model economy choose to work in our calibration year. This suggests that the number of workers who would have been penalized for having short working histories in our model economy is very small.

*Disability pensions.* We model disability pensions explicitly for two reasons: because they represent a large share of all Spanish pensions (10.7 percent of all pensions in 2010), and because, in many cases, disability pensions are used as an alternative route to early retirement.<sup>12</sup> To replicate the current Spanish rules, we assume that there is a minimum disability pension which coincides with the minimum retirement pension. And that the disability pensions are 75 percent of the households' retirement claims. Formally, we compute the disability pensions as follows:

$$p_t = \max\{p_{0t}, 0.75b_t\}. \quad (14)$$

<sup>9</sup>This late retirement premium was introduced in the 2002 reform of the Spanish public pension system.

<sup>10</sup>In Spain normal and maximum pensions are adjusted using the inflation rate and minimum pensions are increased discretionally. This has implied that over the last decade or so the Spanish minimum pension has roughly kept up with per capita GDP, and that the maximum pension and normal pensions have decreased as a share of per capita GDP. This little known fact is known as *the silent reform*.

<sup>11</sup>The Spanish Régimen General de la Seguridad Social is the most important pension program in the Spanish Social Security System. For instance, 82.1 percent of the affiliated workers and 54.9 percent of existing pensions belonged to this program in 2010.

<sup>12</sup>See Boldrin and Jiménez-Martín (2002) for an elaboration of this argument.

*The pension reserve fund.* We assume that pension system surpluses,  $(T_{st} - P_t)$ , are deposited into a non-negative pension reserve fund which evolves according to

$$F_{t+1} = (1 + r^*)F_t + T_{st} - P_t \tag{15}$$

where  $F_t$  denotes the value of the pension reserve fund at the beginning of period  $t$ , and parameter  $r^*$  is the exogenous rate of return of the fund's assets. We assume that, when the pension reserve fund runs out, the government borrows as much as necessary at the same rate  $r^*$  to finance the pension system deficits. We make this choice to minimize the large distortions that the growing pension system deficits would have created if they were financed otherwise.

## 2.5 Market Arrangements

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

*Assets.* We assume that the households in our model economy cannot borrow. Since leisure is an argument of their utility function, this borrowing constraint can be interpreted as a solvency constraint that prevents the households from going bankrupt in every state of the world. These restrictions give the households a precautionary motive to save. They do so accumulating real assets, which we denote by  $a_t$ , and which take the form of productive capital. For computational reasons we restrict the asset holdings to belong to the discrete set  $\mathcal{A} = \{a_0, a_1, \dots, a_n\}$ . We choose  $n = 99$ , and assume that  $a_0 = 0$ , that  $a_{99} = 75$ , and that the spacing between points in set  $\mathcal{A}$  is increasing.<sup>13</sup>

*Pension Rights.* We assume that the workers' pension rights belong to the discrete set  $B_t = \{b_{0t}, b_{1t}, \dots, b_{mt}\}$ .<sup>14</sup> Let parameter  $N_b$  denote the number of years of contributions that are taken into account to calculate the pension. Then, when a worker's age is  $R_0 - N_b < j < R_0$ , the  $b_{jt}$  record the average labor income earned by that worker since age  $R_0 - N_b$ . And when a worker is older than  $R_0$ , the  $b_{jt}$  record the average labor income earned by that worker during the previous  $N_b$  years. We assume that  $b_{0t} = 0$ , and that  $b_{mt} = a_{15}\bar{y}_t$ , where  $a_{15}\bar{y}_t$ , and as we said before, denotes the maximum earnings covered by the pension system. We also assume that  $m = 9$  and that the spacing between points on  $B_t$  is increasing.

*Pensions.* We assume that both the disability and retirement pensions belong to set  $P_t = \{p_{0t}, p_{1t}, \dots, p_{mt}\}$ . The rules of the pension system determine the mapping from pension rights into pensions, and workers take into account this mapping when they decide how much to work and when to retire. Since this mapping is single valued, and cardinality of the set of pension rights,  $B_t$ , was 10,  $m = 9$  also for  $P_t$ . Finally, we assume that the distances between any two consecutive points in the pensions set is increasing.

<sup>13</sup>In overlapping generation models with finite lives and no altruism there is no need to impose an upper bound for set  $\mathcal{A}$  since households who reach the maximum age will optimally consume all their assets. İmrohoroğlu, İmrohoroğlu, and Joines (1995) make a similar point.

<sup>14</sup>Set  $B_t$  changes with time because its upper bound is the maximum covered earnings which are proportional to per capita output.

## 2.6 The Households' Decision Problem

We assume that the households in our model economy solve the following decision problem:

$$\max E \left\{ \sum_{j=20}^{100} \beta^{j-20} \psi_{jt} [c_{jht}^\alpha (1 - l_{jht})^{(1-\alpha)}]^{(1-\sigma)} / 1 - \sigma \right\} \quad (16)$$

subject to

$$c_{jht} + a_{jht+1} + \tau_{jht} = y_{jht} + a_{jht} \quad (17)$$

and where

$$\tau_{jht} = \tau_a(y_{jht}^a) + \tau_{st}(y_{jht}^l) + \tau_y(y_{jht}^b) + \tau_{ct}(c_{jht}) \quad (18)$$

$$y_{jht} = y_{jht}^a + y_{jht}^l + p_t \quad (19)$$

$$y_{jht}^a = a_{jht} r_t \quad (20)$$

$$y_{jht}^l = \epsilon_{jh} s_t l_{jht} w_t \quad (21)$$

$$y_{jht}^b = y_{jht}^a + y_{jht}^l + p_t - \tau_a(y_t^a) - \tau_s(y_t^l) \quad (22)$$

where  $a_{jht} \in \mathcal{A}$ ,  $p_t \in P_t$ ,  $s_t \in \omega$  for all  $t$ , and  $a_{jh0}$  is given. Notice that every household can earn capital income, only workers can earn labor income, and only retirees and disabled households receive pensions.

## 2.7 Definition of Equilibrium

Let  $j \in J$ ,  $h \in H$ ,  $e \in \mathcal{E}$ ,  $a \in \mathcal{A}$ ,  $b_t \in B_t$ , and  $p_t \in P_t$ , and let  $\mu_{j,h,e,a,b,p,t}$  be a probability measure defined on  $\mathfrak{R} = J \times H \times \mathcal{E} \times \mathcal{A} \times B_t \times P_t$ .<sup>15</sup> Then, given initial conditions  $\mu_0$ ,  $A_0$ ,  $E_0$ ,  $F_0$ , and  $K_0$ , a competitive equilibrium for this economy is a government policy,  $\{G_t, P_t, Z_t, T_{at}, T_{st}, T_{yt}, T_{ct}, E_{t+1}, F_{t+1}\}_{t=0}^\infty$ , a household policy,  $\{c_t(j, h, e, a, b, p), l_t(j, h, e, a, b, p), a_{t+1}(j, h, e, a, b, p)\}_{t=0}^\infty$ , a sequence of measures,  $\{\mu_t\}_{t=0}^\infty$ , a sequence of factor prices,  $\{r_t, w_t\}_{t=0}^\infty$ , a sequence of macroeconomic aggregates,  $\{C_t, I_t, Y_t, K_{t+1}, L_t\}_{t=0}^\infty$ , a function,  $Q$ , and a number,  $r^*$ , such that:

- (i) The government policy and  $r^*$  satisfy the consolidated government and pension system budget constraint described in Expression (6) and the the law of motion of the pension system fund described in Expression (15).
- (ii) Firms behave as competitive maximizers. That is, their decisions imply that factor prices are factor marginal productivities  $r_t = f_1(K_t, A_t L_t) - \delta$  and  $w_t = f_2(K_t, A_t L_t)$ .
- (iii) Given the initial conditions, the government policy, and factor prices, the household policy solves the households' decision problem defined in Expressions (16), through (22).
- (iv) Gross savings, consumption, factor inputs, pension payments, tax revenues, and accidental bequests

<sup>15</sup>Recall that, for convenience, whenever we integrate the measure of households over some dimension, we drop the corresponding subscript.

are obtained aggregating over the model economy households as follows:

$$K_t = \int a_{jht} d\mu_t \quad (23)$$

$$C_t = \int c_{jht} d\mu_t \quad (24)$$

$$L_t = \int \epsilon_{jh} s_t l_{jht} d\mu_t \quad (25)$$

$$P_t = \int p_t d\mu_t \quad (26)$$

$$T_{ct} = \int \tau_{ct}(c_{jht}) d\mu_t \quad (27)$$

$$T_{at} = \int \tau_a(y_{jht}^a) d\mu_t \quad (28)$$

$$T_{st} = \int \tau_s(y_{jht}^l) d\mu_t \quad (29)$$

$$T_{yt} = \int \tau_y(y_{jht}^b) d\mu_t \quad (30)$$

$$E_t = \int (1 - \psi_{jt}) a_{jht+1} d\mu_t \quad (31)$$

where  $y_{jht}^a = a_{jht} r_t$ ,  $y_{jht}^l = \epsilon_{jh} s_t l_{jht} w_t$ , and  $y_{jht}^b = y_{jht}^a + y_{jht}^l + p_t - \tau_a(y_t^a) - \tau_s(y_t^l)$ , and all the integrals are defined over the state space  $\mathfrak{R}$ .

(v) Net investment  $I_t$  is

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

(vi) The goods market clears:

$$C_t + \int (a_{jht+1} - a_{jht}) d\mu_t + G_t + [Z_t + (F_{t+1} - F_t)] = F(K_t, A_t L_t). \quad (33)$$

The last term of the left-hand side of this expression is not standard. Transfers other than pensions,  $Z_t$ , show up in this expression because we assume that the government throws them to the sea. And the change in the value of the pension reserve fund,  $(F_{t+1} - F_t)$  shows up because pension system surpluses are invested in the pension fund and pension system deficits are financed with the fund.<sup>16</sup>

(vii) The law of motion for  $\mu_t$  is:

$$\mu_{t+1} = \int_{\mathfrak{R}} Q_t d\mu_t. \quad (34)$$

Describing function  $Q$  formally is complicated because it specifies the transitions of the measure of households along its six dimensions: age, education level, employment status, assets holdings, pension rights, and pensions. An informal description of this function is the following:

We assume that new-entrants, who are 20 years old, enter the economy as able-bodied workers, that they draw the stochastic component of their endowment of efficiency labor units from its invariant distribution, and that they own zero assets and zero pension rights. Their educational shares are exogenous and they determine the evolution of  $\mu_{ht}$ . We also assume that new-entrants who are older than 20 replicate the age, education, employment status, wealth, pension rights, and pensions share distribution of the existing population.

<sup>16</sup>The last term of the left-hand side of Expression (33) would show up as net exports in the standard national income and product accounts.

The evolution of  $\mu_{jht}$  is exogenous, it replicates the Spanish demographic projections, and we compute it following a procedure that we describe in Appendix 1 below. The evolution of  $\mu_{et}$  is governed by the conditional transition probability matrix of its stochastic component, by the probability of becoming disabled, and by the optimal decision to retire. The evolution of  $\mu_{at}$  is determined by the optimal savings decision, the unintentional bequests, and the age-dependent net migration flows estimated by the Spanish *Instituto Nacional de Estadística (INE)*. The evolution of  $\mu_{bt}$  is determined by the rules of the Spanish public pension system which we have described in Section 2.1. Finally, we assume that once a household retires or becomes disabled its retirement or disability pensions never change.

### 3 Calibration

To calibrate our model economy we do the following: First, we choose a calibration target country —Spain in this article— and a calibration target year —2010 in this article. Then we choose the initial conditions and the parameter values that allow our model economy to replicate as closely as possible selected macroeconomic aggregates and ratios, distributional statistics, and the institutional details of our chosen country in our target year.

#### 3.1 Initial conditions

To determine the initial conditions, first we choose an initial distribution of households,  $\mu_0$ . We take the measure  $\mu_{j,2010}$  for all  $j = \{20, 21, \dots, 100\}$  directly from the Spanish economy published by the *National Institute of Statistics (INE)*. We also take the measure  $\mu_{j,h,2010}$  directly from the Spanish economy published by the INE. Specifically, we take from the *Encuesta de Población Activa* the population aged 20 and over by level of education attained and age group, for both males and females. The initial distribution of households implies an initial value for the capital stock. This value is  $K_{2010} = 13.4964$ . The initial distribution of households and the initial survival probabilities determine the initial value of unintentional bequests,  $E_{2010}$ . We must also specify the initial values for the productivity process,  $A_{2010}$ , and for the pension reserve fund  $F_{2010}$ . Since  $A_{2010}$  determines the units which we use to measure output and does nothing else, we choose  $A_{2010} = 1.0$ . Finally, our choice for the initial value of the pension reserve fund is  $F_{2010} = 0.0612 Y_{2010}^*$ , where  $Y_t^*$  denotes output at market prices, which we define as  $Y_t^* = Y_t + T_{ct}$ . This number corresponds to the value of the Spanish pension fund at the end of 2010.

#### 3.2 Parameters

When all is told and once the initial conditions are specified, to characterize our model economy fully, we must choose the values of a total of 50 parameters. Of these 50 parameters, 3 describe the household preferences, 21 the process on the endowment of efficiency labor units, 4 the disability risk, 3 the production technology, 12 the pension system rules, and 7 the remaining components of the government policy. To choose the values of these 50 parameters we need 50 equations or calibration targets which we describe below.

#### 3.3 Equations

To determine the values of the 50 parameters that identify our model economy, we do the following. First, we determine the values of a group of 31 parameters directly using equations that involve one parameter only. To determine the values of the remaining 19 parameters we construct a system of 19 non-linear equations. Most of these equations require that various descriptive statistics of our model economy replicate the values

of the corresponding Spanish statistics in 2010. We describe the determination of both sets of parameters in the subsections below.

### 3.3.1 Parameters determined using single equations

*The life-cycle profile of earnings.* We measure the deterministic component of the process on the endowment of efficiency labor units independently of the rest of the model. We estimate the values of parameters of the three quadratic functions that we describe in Expression (1), using the age and educational distributions of hourly wages reported by the *Instituto Nacional de Estadística* (INE) in the *Encuesta de Estructura Salarial* (2010) for Spain. This procedure allows us to identify the values of 9 parameters.

*The disability risk.* We want the probability of becoming disabled to approximate the data reported by the *Boletín de Estadísticas Laborales* (2007) for the Spanish economy. We use this dataset to estimate the values of parameters  $a_4$  and  $a_5$  of Expression (3) using an ordinary least squares regression of  $q_j$  on  $j$ . According to the *Instituto de Mayores y Servicios Sociales*, in 2008 in Spain 62.6 percent of the total number of disabled people aged 25 to 44 years old had not completed high school, 26.9 percent had completed high school, and the remaining 10.5 percent had completed college. We use these shares to determine the values of parameters  $a_6$  and  $a_7$  of Equation (4). Specifically, we choose  $a_6 = 0.269/0.626 = 0.4297$  and  $a_7 = 0.105/0.626 = 0.1677$ . This procedure allows us determine the values of 4 parameters.

*The pension system.* In 2010 in Spain, the payroll tax rate paid by households was 28.3 percent and it was levied only on the first 44,772 euros of annual gross labor income. Hence, the maximum contribution was 12,670 euros which correspond to 45.53 percent of the Spanish GDP per person who was 20 or older. To replicate this feature of the Spanish pension system we choose the value of parameter  $a_{13}$  of our payroll tax function to be  $a_{13} = 0.4553$ .

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

We assume that the minimum pension, the maximum pension, and the maximum covered earnings are directly proportional to per capita income. Our targets for the proportionality coefficients are  $b_{0t} = 0.1731$ ,  $b_{mt} = 1.2567$ , and  $a_{15} = 1.6089$ . These numbers correspond to their values in 2010 in Spain for workers included in the *Régimen General*.<sup>17</sup>

We choose our first and normal retirement ages to be  $R_0 = 60$  and  $R_1 = 65$ . In Spain the first retirement age was 60 until 2002. This rule was changed in 2002 when the first retirement age was changed to 61, with some exceptions. We choose  $R_0 = 60$  because in 2010 a large number of workers were still retiring at that age.<sup>18</sup>

To identify the early retirement penalty function, we choose  $a_{16} = 0.4$ , and  $a_{17} = 0.08$ . This is because we have chosen  $R_0 = 60$ , and because in Spain the penalties for early retirement are 8 percent for every year before age 65. Finally, for the rate of return on the pension reserve fund's assets we choose  $r^* = 0.02$ .<sup>19</sup> These choices allow us to determine directly the values of 10 parameters.

<sup>17</sup>Specifically, in 2010 the minimum retirement pension in Spain was 4,817 euros, the maximum pension was 34,970 euros, the maximum covered earnings were 44,772 euros, and GDP per person who was 20 or older was 27,827 euros.

<sup>18</sup>In 2010 in Spain 22.4 percent of the people who opted for early retirement were 60 years old or younger. And 5.78 percent of the total number of retirees were 60 or younger. See *Ministerio de Trabajo e Inmigración (MTIN)*, *Anuario de Estadísticas* 2010 (<http://www.empleo.gob.es/estadisticas/ANUARIO2010/PEN/index.htm>).

<sup>19</sup>In Díaz-Giménez and Díaz-Saavedra (2009) we also run simulations  $r^* = 0.01$ ,  $r^* = 0.03$ , and  $r^* = 0.04$ . We found that the changes implied by the various values of  $r^*$  were small and that they did not modify the qualitative conclusions of that article.

Table 1: The values of 38 of the model economy parameters

	Parameter	Value
Parameters obtained directly		
<i>Earnings Life-Cycle</i>		
	$a_{1,1}$	0.9189
	$a_{1,2}$	0.8826
	$a_{1,3}$	0.5064
	$a_{2,1}$	0.0419
	$a_{2,2}$	0.0674
	$a_{2,3}$	0.1648
	$a_{3,1}$	0.0006
	$a_{3,2}$	0.0008
	$a_{3,3}$	0.0021
<i>Disability Risk</i>		
	$a_4$	0.000449
	$a_5$	0.0924
	$a_6$	0.4291
	$a_7$	0.1677
<i>Preferences</i>		
Curvature	$\sigma$	4.0000
<i>Technology</i>		
Capital share	$\theta$	0.3669
Productivity growth rate	$\gamma$	0.0000
<i>Public Pension System</i>		
Maximum early retirement penalty	$a_{16}$	0.4000
Early retirement penalty per year	$a_{17}$	0.0800
Number of years of contributions	$N_b$	15
First retirement age	$R_0$	60
Normal retirement age	$R_1$	65
Rate of return for the pension fund	$r^*$	0.0200
<i>Government Policy</i>		
Household Income Tax function		
	$a_9$	0.4500
	$a_{11}$	1.0710
Parameters determined by guesses for $(K, L)$		
<i>Public Pension System</i>		
Payroll tax cap	$a_{13}$	0.4553
Maximum covered earnings	$a_{15}$	1.6089
Minimum retirement pension	$b_{0t}$	0.7120
Maximum retirement pension	$b_{mt}$	5.1691
<i>Government Policy</i>		
Government consumption	$G$	0.8493
Capital income tax rate	$a_8$	0.1882
Consumption tax rate	$a_{12}$	0.2091
Parameters determined solving the system of equations		
<i>Preferences</i>		
Leisure share	$\alpha$	0.3397
Time discount factor	$\beta$	1.0520
<i>Technology</i>		
Capital depreciation rate	$\delta$	0.0724
<i>Public Pension System</i>		
Payroll tax rate	$a_{14}$	0.2385
Pension replacement rate	$\phi$	0.8279
<i>Government Policy</i>		
Household Income tax function	$a_{10}$	0.0607
Government transfers	$Z$	-0.0807

*Government policy.* We choose directly the values of government consumption,  $G_t$ , of the tax rate on capital income,  $a_8$ , of parameters  $a_9$  and  $a_{11}$  of the household income tax function, and of the tax rate on consumption,  $a_{12t}$ . We describe our procedure to choose the value of these five parameters in Appendix 2.

*Preferences.* Of the four parameters in the utility function, we choose the value of  $\sigma$  directly. Specifically, we choose  $\sigma = 4.0$ . This choice and the value of the share of consumption in the utility function, imply that the relative risk aversion in consumption is 1.8937, which falls within the 1.5-3 range which is standard in the literature.

*Technology.* According to the OECD data, the capital income share in Spanish GDP was 0.3669 in 2008. Consequently, we choose  $\theta = 0.3669$  directly. We also choose the growth rate of total factor productivity directly. We discuss this choice in Appendix 3 below.

Specifically, we assume that the value of the growth rate of the labor-augmenting productivity process is  $\gamma = 0$ . The rationale for this choice is as follows. According to Balmaseda, Melguizo, and Taguas (2006), between 1988 and 2004, the average annual productivity growth rate, measured as output per employee, was only 0.6 percent. Moreover, Boldrin, Conde-Ruiz, and Díaz-Giménez (2010) show that for the period 1999-2006, the growth rate of labor productivity has been negative. Consequently, our choice resembles the average behavior of Spanish labor productivity during the last few years.

*Adding up.* So far we have determined the values of 31 parameters directly. We report their values in the first two blocks of Table 1.

### 3.3.2 Parameters determined using a system of equations

We still have to determine the values of 19 parameters. To find the values of those 19 parameters we need 19 equations. Of those equations, 14 require that model economy statistics replicate the value of the corresponding statistics for the Spanish economy in 2010. The government budget constraint allows us to determine the value of  $Z/Y^*$  residually. And the 4 remaining equations are normalization conditions.

Table 2: Macroeconomic Aggregates and Ratios in 2010 (%)

	$C/Y^{*a}$	$K/Y^{*b}$	$h^c$	$T_y/Y^*$	$T_s/Y^*$	$P/Y^*$
Spain	51.5	3.28	34.4	7.4	10.1	10.3

<sup>a</sup>Variable  $Y^*$  denotes GDP at market prices.

<sup>b</sup>The target for  $K/Y^*$  is in model units and not in percentage terms.

<sup>c</sup>Variable  $h$  denotes the average share of disposable time allocated to the market of those workers aged 55 to 64.

*Aggregate Targets.* We report the values of the 6 Spanish macroeconomic aggregates and ratios that we target in Table 2. According to the Spanish *Encuesta de Empleo del Tiempo (2010)*, the average number of hours worked per worker aged 55 to 64 was 38.5 hours per week. If we consider the endowment of disposable time to be 16 hours per day, the total amount of disposable time is 112 hours per week. Dividing 38.5 by 112 we obtain 34.4 percent which is the share of disposable time allocated to working in the market that we target. Consequently, the Frisch elasticity of labour supply implied in our model is 0.68, which is in the middle of the range of recent econometric estimates. We describe how we obtain the remaining targets in Appendix 1.

*Distributional Targets.* We target the 3 Gini indexes and 5 points of the Lorenz curves of the Spanish distributions of earnings, income and wealth for 2004. We have taken these statistics from Budría and



Díaz-Giménez (2006), and we report them in bold face in Table 6. Castañeda Díaz-Giménez and Rios-Rull (2003) argue in favor of this calibration procedure to replicate the inequality reported in the data. These targets give us a total of 8 additional equations.

*The Government Budget.* The government budget is an additional equation that allows us to obtain residually the government transfers to output ratio,  $Z_t/Y_t^*$ .

*Normalization conditions.* Finally, in our model economy there are 4 normalization conditions. The transition probability matrix on the stochastic component of the endowment of efficiency labor units process is a Markov matrix and therefore its rows must add up to one. This gives us three normalization conditions. We also normalize the first realization of this process to be  $s(1)=1$ .

Table 3: The Stochastic Component of the Endowment Process

		Transition Probabilities			
	Values	$s' = s_1$	$s' = s_2$	$s' = s_3$	$\pi^*(s)^a$
$s = s_1$	1.0000	0.9417	0.0582	0.0000	31.41
$s = s_2$	2.0856	0.0319	0.9680	0.0000	57.25
$s = s_3$	11.2892	0.0000	0.0002	0.9997	11.32

<sup>a</sup> $\pi^*(s)\%$  denotes the invariant distribution of  $s$ .

*Computation.* To determine the values of these 19 parameters first we solve the system of 14 non-linear equations in 14 unknowns that we obtain when we equate the relevant statistics of the model economy to their corresponding Spanish targets. Once we had chosen the best solution to this system, we obtained the values of the remaining 5 parameters from the government budget and from our normalization conditions. In the third block of Table 1 and in the first two blocks of Table 3, we report the values of the 19 unknowns.

## 4 Calibration Results: The Benchmark Model

We check that our theoretical framework is consistent with Spanish data. The single most important feature of the Spanish economy that our model economy should approximate is the retirement behavior of Spanish households if we want to consider seriously our quantitative findings. Consequently, we begin this section by analyzing in great detail the statistics characterizing retirement behavior, both in Spain and in our benchmark model economy. Subsequently, we consider the hours worked after the age of 55, the main aggregates and ratios, and finally we examine the distributions on earnings, income, pensions and wealth.

### 4.1 Retirement behavior

*An initial overview* In Table 4 we report the average retirement ages and the participation rates of those aged 60 to 64. The table shows that the model predicts an average retirement age of 63.7 years, and that this number is 1.4 years higher than its empirical counterpart. The model also predicts increasing average retirement ages in proportion to the number of years of education. Unfortunately, the actual statistics are not available, but this relationship is highly plausible, since participation rates in Spain also increase with education (see column 3 of Table 4).

The total participation rate of those households aged 60 to 64 is 55.8 percent in our model economy, and 56.6 percent in Spain. The table also shows that participation rates in Spain increase with education. This is because even though all educational types value leisure equally, the foregone labor income (which is the

Table 4: Retirement Ages And Participation Rates

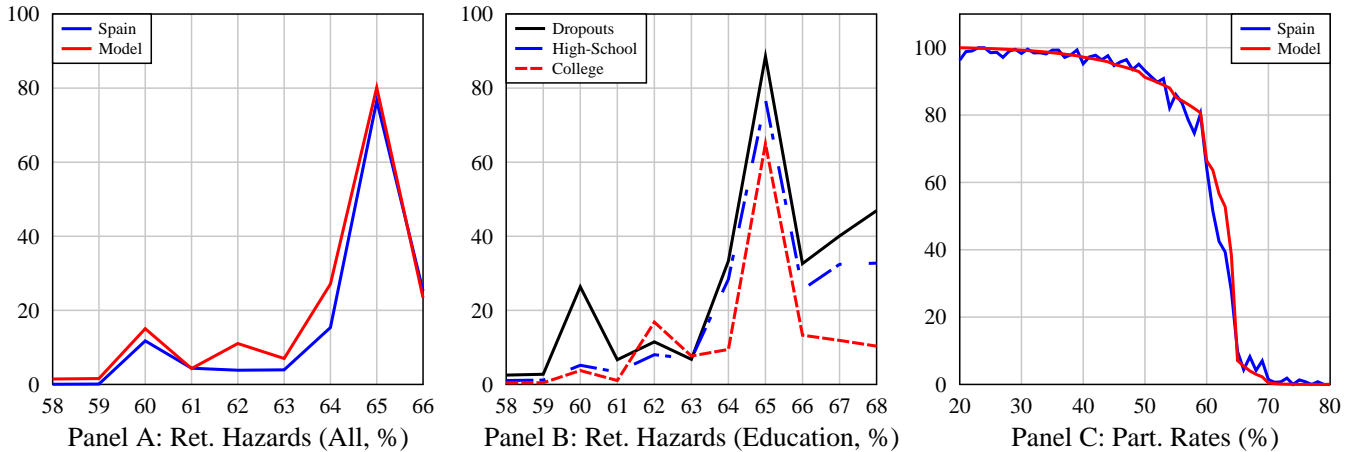
	Avg Ret Ages		Part rates at 60-64 (%)	
	Spain <sup>a</sup>	Model	Spain <sup>b</sup>	Model
All	62.3	63.7	56.6	55.8
Dropouts	<i>n.a.</i>	63.2	45.5	41.7
High School	<i>n.a.</i>	64.2	61.0	69.2
College	<i>n.a.</i>	64.4	75.2	77.6

<sup>a</sup>The Spanish data is for both males and females in 2010 (Source: Eurostat).

<sup>b</sup>The Spanish data is from both the *Encuesta de la Población Activa*, and the *Encuesta de Empleo del Tiempo 2010*, excluding the unemployed and non-participants who do not collect either retirement or disability pensions.

opportunity cost of leisure) is lower for less educated workers. A second reason is that low educated workers are those who most take advantage of early retirement provisions, such as the minimum retirement pension provided by the Spanish pension system. The model successfully reproduces this tendency, and also does a good job in replicating the participation rates for all educational types<sup>20</sup>.

Figure 2: Retirement Hazards From The Labor Force and Participation Rates (%)\*



\* The Spanish data for the retirement hazards is taken from García Pérez and Sánchez-Martín (2012). The Spanish data for the participation rate is computed from the *Encuesta de Empleo del Tiempo (2010)*, reported by the INE.

*Further details.* An examination of other statistics on retirement behavior increases our confidence in our model economy as a tool for policy analysis. Panel A of Figure 2 shows the age-dependent empirical profile for claiming retirement benefits in Spain. This profile, which displays peaks at the first and the normal retirement age, is a common stylized fact across those countries operating a defined benefit pension system (see Gruber and Wise, 1999). Our model economy successfully matches the empirical profile, as the claiming of benefits is also concentrated at the first and normal retirement ages. Close scrutiny reveals that hazard is higher at age 65 in the model economy, reaching 80.1 percent. For Spain, this figure is 71.8.

<sup>20</sup>When making this comparison it must be remembered that there exist certain fundamental differences between Spain and our model economy. In Spain, people of working age fall into one of five categories: employed, unemployed, retired, disabled, and other non-participants. In our model economy we only have three: employed, disabled, and retired. This is why we present the Spanish data in these three categories

Our model economy also predicts a much higher probability of low-educated workers leaving the labor force at the age of 60 (see Panel B of Figure 2). In fact, 80 percent of those who retire at this age are dropout workers. This is consistent with the findings of Sánchez-Martín (2010), who report that at age 60 low income workers have a much higher probability of retiring than high income workers. In both Spain and our model economy, the minimum retirement pension provided by the pension system is mainly behind this fact, since this type of pension strongly affects retirement behavior, and it is currently received by 27 percent of all retirees in Spain, this number reaching 25 percent in our model economy. Workers can receive this type of pension since the first retirement age of 60, and are also aware that delaying the receipt of this minimum amount does not increase it. In other words, a worker entitled to this amount faces a significant implicit tax on continued work. Consequently, workers, and especially low income workers, have the incentive to apply for this benefit at age 60. In our model economy, 95 percent of those who leave the labor force at age 60 receive this minimum pension, while Jiménez-Martín and Sánchez-Martín (2006) find that this figure in Spain is 67 percent.

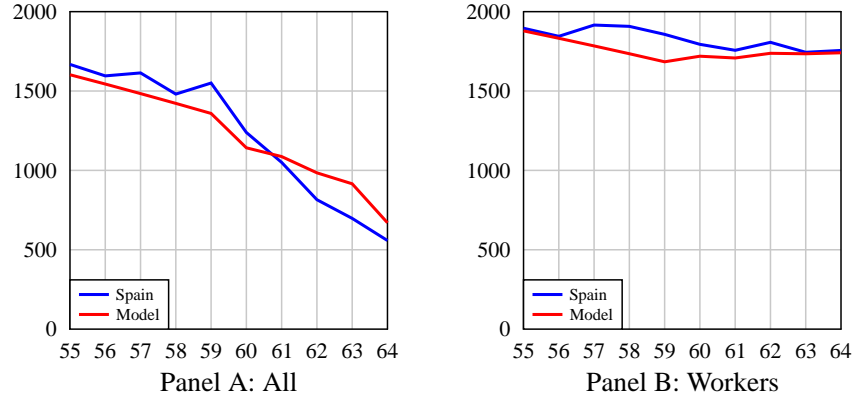
Retirement hazards are lower after age 60 in both Spain and in our model economy, due to the same key economic force. Those workers with pension entitlements higher than the minimum pension, by working one further year can reduce by up to 8 percent the annual early retirement penalty applied to his or her pension. This means that after age 60, many workers face an implicit subsidy to continuing in work, which may amount to 25 percent of their net salary level in the relevant year, as shown by Boldrin et al. (1997). Expressed another way, these workers can increase their Social Security Wealth (SSW) if they choose to work at least one more year<sup>21</sup>. Notice also that this implicit subsidy is reduced as age approaches to 65, because the interaction between labor income dynamics and the Regulatory Base. Consequently, retirement hazards increases after age 61 in both Spain and our model economy.

The picture is different at the age of 65. Because the Spanish pension system provides no economic incentives to delay retirement beyond this age, and also because of the drop in the Regulatory Base resulting from the worker's labor income dynamics, SSW continues to be reduced for most workers who would remain in the labor force. In addition, the marginal tax rate on labor income may turn out to be higher than the marginal tax rate on pension income, due to the high progressivity of the Spanish income tax schedule. Consequently, these workers choose to leave the labor force to avoid the high implicit tax on continuing to work. Boldrin et al. (1997), Argimón et al. (2009), and Sánchez-Martín (2010) find that the probability of retirement at age 65 is independent of salary level, and our model economy replicates this stylized fact reasonably well. For instance, at age 65, retirement hazards are similar for all educational groups, and are over 65 percent (see Panel B of Figure 2).

Finally, Panel C of Figure 2 compares the age-dependent aggregate participation rates in the data and in our model economy. The data are based on the *Encuesta de Empleo del Tiempo (2010)*, reported by the INE. This panel shows that our model economy is successful in matching quantitatively the decline in the participation rate starting at age 50, more sharply after age 60, in Spain.

*Overall assessment.* An accurate assessment of the questions we pose in this paper requires a model economy that captures the key institutional and economic forces leading to retirement. Our model economy describes in great detail both the Spanish tax system and the rules of the Spanish Public Pension System. It also incorporates a calibration procedure for the earnings process which is consistent with earnings inequality in Spain (see below). Thus, our model economy successfully matches distribution of retirement and other key features of retirement behavior found in Spanish data. This is particularly remarkable since the calibration procedure did not explicitly target the various facts on retirement behavior.

Figure 3: Mean Annual Hours Worked (Age 55-64)



\* The Spanish data is computed from the *Encuesta de Empleo del Tiempo (2010)*, reported by the INE.

## 4.2 Labor Supply Late in the Life Cycle.

The calibration procedure did not explicitly target various facts regarding labor supply. However, it is important to point out that our model economy does a good job in accounting for some facts on labor supply. Figure 3 reports mean annual hours worked for individuals in the 55-64 age group both in the model and in the Spanish data, as this paper also focuses on labor supply for individuals in this age group. Panel A shows that the model is quantitatively consistent with the fact that the profile for average annual hours declines late in the working lifetime. The decline in working hours in the Spanish data is mainly driven by the extensive margin, although there is also a small decline in hours worked along the intensive margin late in the life cycle (see Panel B). The model is quantitatively consistent with these patterns in the data.

## 4.3 Aggregates and Ratios

*Macroeconomic Aggregates and Ratios.* In Table 5 we report the macroeconomic aggregates and ratios in Spain and in our benchmark model economy for 2010. We find that our benchmark model economy does a good job in replicating most of the values for the chosen targets.

Table 5: Macroeconomic Aggregates and Ratios in 2010 (%)

	$C/Y$	$K/Y$	$h$	$T_y/Y^*$	$T_s/Y^*$	$P/Y^*$
Spain	51.5	3.28	34.4	7.4	10.1	10.3
Model	51.3	3.28	33.1	7.7	10.1	10.2

## 4.4 Inequality

*Distributional statistics* In Table 6 we report the Gini indices and selected points of the Lorenz curves for earnings, income, pensions and wealth in Spain and in our model economy. The statistics reported in bold

<sup>21</sup>Other workers, who expect an unusually low salary level, face significant implicit taxes on continued work, as the Regulatory Base would be reduced.

are our eight calibration targets. The source for the Spanish data on earnings, income and wealth is the 2004 Financial Survey of Spanish Families, as reported in Budría and Díaz-Giménez (2006). We take the Gini index of pensions from Conde-Ruiz and Profeta (2007). The model economy statistics correspond to 2010. In Figure 3 we plot the Lorenz curves of these distributions in our model economy.

Table 6: The Distributions of Earnings, Income, Pensions, and Wealth\*

		Bottom Tail			Quintiles					Top Tail		
	Gini	1	1-5	5-10	1st	2nd	3rd	4th	5th	10-5	5-1	1
The Earnings Distributions (%)												
Spain	<b>0.49</b>	0.0	0.7	1.2	<b>5.3</b>	10.9	<b>16.2</b>	23.3	<b>44.3</b>	10.9	11.5	5.6
Model	0.47	0.1	0.8	1.3	5.4	9.5	13.5	16.1	55.5	17.4	17.9	6.5
The Income Distributions (%)												
Spain	<b>0.42</b>	0.0	0.7	1.1	5.1	10.1	15.2	22.5	47.1	11.1	12.8	6.7
Model	0.43	0.1	1.0	1.6	6.5	9.8	13.9	17.4	52.3	14.7	18.0	6.8
The Pensions Distributions (%)												
Spain	0.32	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Model	0.36	0.4	1.8	2.2	8.8	9.9	15.1	19.3	46.9	15.5	12.8	3.2
The Wealth Distributions (%)												
Spain	<b>0.57</b>	-0.1	0.0	0.0	0.9	<b>6.6</b>	12.5	<b>20.6</b>	59.5	12.5	16.4	13.6
Model	0.55	0.0	0.0	0.0	1.2	7.2	14.1	21.4	56.1	15.3	21.0	5.5

\*The source for the Spanish data of earnings, income, and wealth is the 2004 *Encuesta Financiera de las Familias Españolas* as reported in Budría and Díaz-Giménez (2006). We take the Pensions Gini index in Spain from Conde-Ruiz and Profeta (2007). The model economy statistics correspond to 2008. The statistics in bold face have been targeted in our calibration procedure.

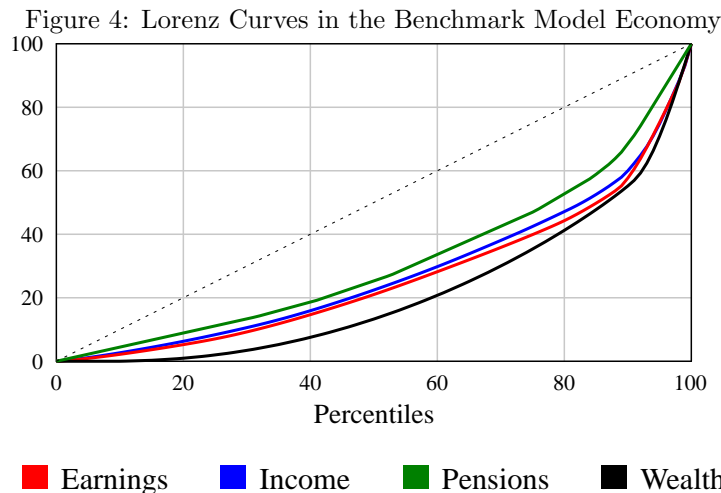
We find that our heterogeneous household model economy replicates all the Spanish Gini indices reasonably well. When we compare the earnings and income shares of the quintiles in the model economy, we find that the top quintiles of these two distributions earn more than in Spain. The fact that the model economy can account reasonably well for both the Lorenz income curve and the Gini pension index is particularly remarkable, since we have not used any of its points as our calibration targets. We also find that wealth is similarly concentrated in our model economy and in Spain. Despite this, the greatest differences between our heterogeneous household model economy and the Spanish data lie in the top 1 percent of wealth distribution, since wealth is considerably more concentrated in Spain. This disparity was expected, because in general overlapping generations economies fail to account for the large shares of wealth owned by the richest households in the data.<sup>22</sup>

## 5 The Reforms

*The Benchmark Model Economy.* In the benchmark model economy, the social security system remains unchanged so that the first and the normal retirement ages remain at 60 and 65 years forever.

*The Reformed Model Economies.* We study the individual and aggregate consequences of social security reforms aimed at delaying retirement. To do so, we compare the benchmark model economy with two reformed model economies. In our first reformed model economy, which we call *Reform 1*, we assume that the government eliminates the possibility for a worker to retire early. This implies that after this reform, workers can only claim social security benefits from the normal retirement age of 65. In our second reformed model economy, which we call *Reform 2*, we assume that the government increases the statutory retirement ages by two years so the first retirement age increases from 60 to 62 and the normal retirement age from 65

<sup>22</sup>See Castañeda et al. (2003) for an elaboration of this argument.



to 67. Finally, we assume that the reforms are adopted in 2013, that they were completely unexpected, and that they affect every household member who had not retired by the end of 2012.

## 6 The Scenarios

We simulate all the model economies under the assumption of fixed prices. Specifically, we assume as factor prices those obtained in the initial equilibrium of the benchmark model economy, and the rationale for this choice is that our exercises can be considered as simulations under the assumption of a small open economy, as it is the case of Spain, in which capital flows freely across countries and the capital-labor ratio is adjusted to achieve given factor price levels. The benchmark and the reformed model economies also share the initial conditions described above and the demographic, educational, and growth scenarios that we now describe.

*Demographic Scenario.* The demographic scenario of our three model economies replicates the demographic projections for Spain for the period 2010–2052 estimated by the Spanish *National Institute of Statistics* (INE). In Appendix 1 we describe in detail the procedure that we use to compute the age distribution,  $\mu_{jt}$ , for  $j = 20, 21, \dots, 100$  and  $t = 2010, 2011, \dots, 2052$  from the INE’s projections.<sup>23</sup>

*Educational Scenario.* The initial educational distribution of our model economy replicates the shares reported for the *Encuesta de Población Activa*, from the Spanish National Institute of Statistics, for 2010. We assume that this educational distribution is not invariant, so to simulate this transition we assume that from 2011, newborns aged 20 enter to the economy with the same educational levels of the most educated age group so far, which is the one born between 1980 and 1984. Consequently, the shares of dropouts, high school, and college workers aged 20 to 64 vary from 19, 60, and 21 percent in 2010 to 9, 65, and 26 percent in 2050 (see Panel B of Figure ??, in Appendix 1).

*Growth Scenario.* We assume that the value of the growth rate of the labor-augmenting productivity process is  $\gamma_t = 0, \forall t$ . The rationale for this choice is as follows. According to Balmaseda, Melguizo, and Taguas (2006), between 1988 and 2004, the average annual productivity growth rate, measured as output per employee, was only 0.6 percent. Moreover, Boldrin, Conde-Ruiz, and Díaz-Giménez (2010) show that for the period 1999–2006, the growth rate of labor productivity has been negative. Consequently, our choice resembles the average behavior of Spanish labor productivity during the last years<sup>24</sup>.

<sup>23</sup>The INE’s demographic projections can be found at [http://www.ine.es/inebmenu/mnu\\_cifraspob.htm](http://www.ine.es/inebmenu/mnu_cifraspob.htm).

<sup>24</sup>Note however that in our model economies there are two other sources of output growth: demographic and educational

## 7 The Results

In this section we compare the results obtained when simulating the three model economies described above. To make the comparisons meaningful, we assume that the sequences of government expenditures, and the consumption, capital and personal income tax rates are identical in the benchmark and the reformed model economies, and they remain unchanged at their 2010 values<sup>25</sup>. The benchmark and the reformed model economies differ only in the consumption, payroll tax, and income tax collections, in the social security payments, and in the unintentional bequests, which are endogenous. And in the government transfers, which we adjust to satisfy the government budget.

### 7.1 Social Security Sustainability

*Retirement behavior and pensions.* In the top panels of Figure 5, we compare the evolution for the average retirement pensions and age, and the participation rate of those aged 60 to 70 years. According to our benchmark model economy, the average retirement age is predicted to increase over the next 40 years due to the change in the educational composition of the labor force. As this educational transition increases the share of more educated workers, the average retirement age increases because more educated workers leave the labor market later.

Both reforms increase the average retirement age. After the first reform, the average retirement age initially increases by 1.5 years, and in the long run it is 0.6 years higher than in the benchmark economy<sup>26</sup>. On the other hand, increasing both legal retirement ages by two years increases the average retirement age by around 1.6 years (see Panel C of Figure 5). Consequently, both reforms increase the participation rates of those aged 60 to 70. The elimination of the early retirement scheme increases the long-run participation rate by more than 4 percentage points, while the rise in both legal retirement ages significantly increases this rate by almost 12 percentage points (see Panel B of Figure 5).

However, these reforms have a different effect on the average retirement pension<sup>27</sup>. Specifically, the first reform increases this average benefit by 2.5 percent in 2050, while the second reform decreases the average pension by 2.7 percent that same year. To understand this difference, consider the case of an old-age worker who, after the second reform, delays her retirement from the labor market by two years. In this case, her social security benefits decrease because the regulatory base decreases, since her earnings in the two additional years of work are below her average earnings of the last 15 years. This is due to the earnings dynamics at older ages, that is, old-age workers are less productive and they also devote less time to market activities than younger workers. This same earnings dynamics effect is present after the first reform, but is more than compensated for by the 8 percent annual increase in social security benefits brought about by the disappearance of early retirement penalizations.

*Social security budget.* In the bottom panels of Figure 5 we compare social security deficits and funds<sup>28</sup>. According to our results, the elimination of the early retirement scheme increases payroll tax collections by 0.5 percent in 2050. However, and since higher retirement ages are partly compensated for by the higher social security benefits, this reform only reduces social security expenditures by 0.6 percent that same year.

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changes. The benchmark model economy and the the reformed economies share the educational and demographic transitions and the value of  $\gamma$ . But output grows at different rates in the three model economies because of the endogenous changes brought about by the reforms.

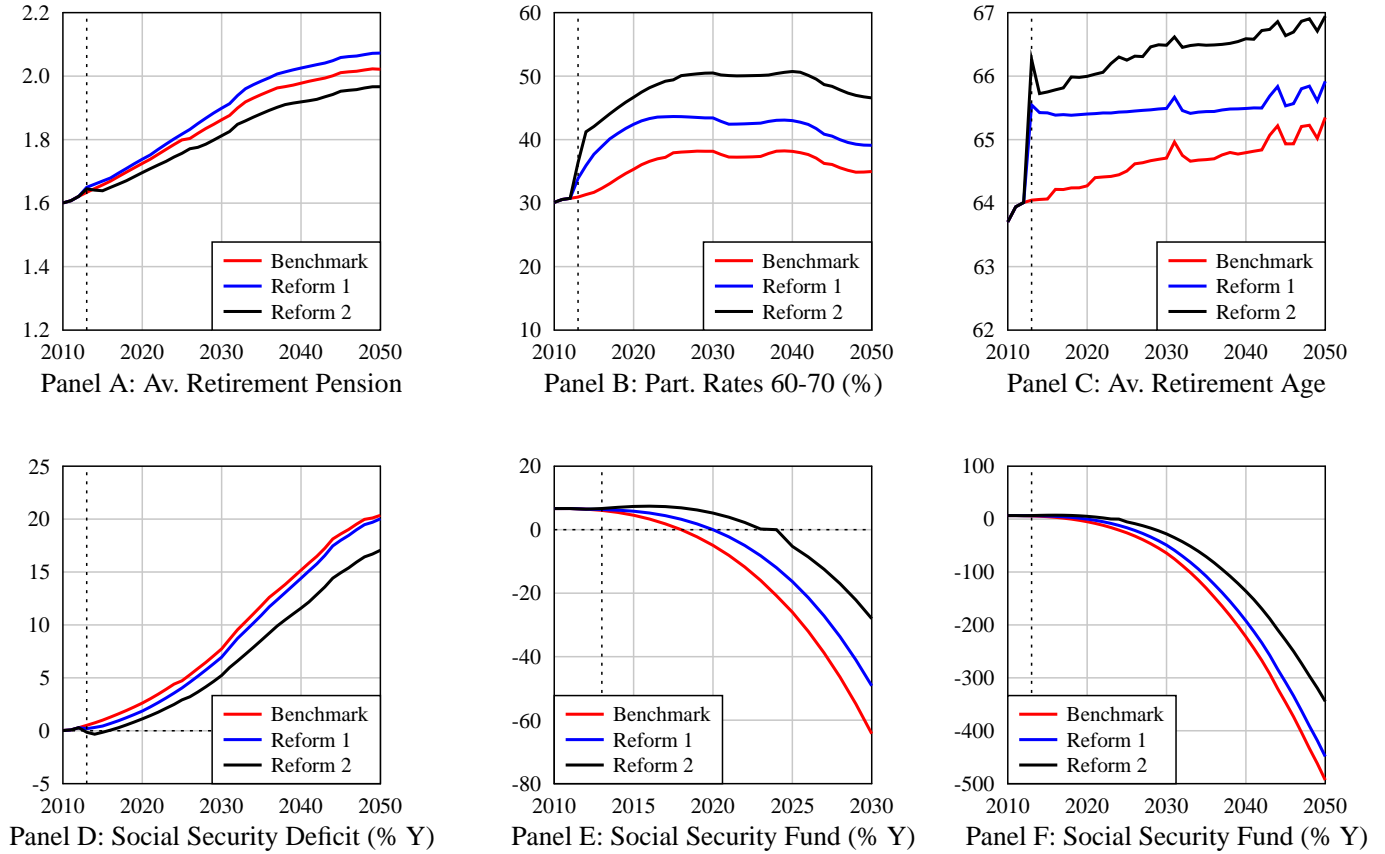
<sup>25</sup>In the bechmark model economy, we keep constant at its 2010 value de ratio Government Consumption to Output.

<sup>26</sup>This drop in the difference is due to the long-run drop in the share of dropouts, which is the educational group that makes more use of the early retirement scheme.

<sup>27</sup>The average retirement pension increases in the benchmark economy due to educational transition. As each cohort of new retirees is more educated, they are entitled to higher pensions as a result of their higher past earnings.

<sup>28</sup>Our benchmark model economy predicts that, as a consequence of the persistent social security budgetary imbalance brought about by the severe expected aging process in Spain, the social security fund will be depleted by 2018, and this fund will be -494 percent of output in 2050. These numbers, however, do not reflect the recent social security reforms approved by the Spanish government in 2011 and 2013; reforms that were designed to reduce long-run social security expenditures.

Figure 5: Social Security Sustainability



Consequently, the elimination of the early retirement scheme delays the depletion of the social security fund by only two years, from 2018 to 2020, and has no significant effect on the long-run social security deficit (see Panels D, E, and F of Figure 5)<sup>29</sup>.

The picture is different when both legal retirement ages are delayed. Specifically, long-run payroll tax collections increase by 4.5 percent and social security expenditure is 7.3 percent lower. These differences regarding the first reformed economy are directly related to the different behavior of both the participation rates of elderly and the average retirement pension. Consequently, this reform delays the depletion of the social security fund by 6 years and also reduces the long-run social security deficit by 3.3 points of output, so that the social security debt decreases from 494 to 344 percent of output in 2050 (see Panel F of Figure 5). These results then show that some reforms may succeed in changing the retirement pattern, but they may not affect the social security budget, as in the case of eliminating the early retirement scheme in Spain. This is because lifetime benefits, especially those available to early claimants, are designed to be approximately equal regardless of the age when they are first collected. Put differently, eliminating early retirement provisions does not ease the burden of an aging population when benefits taken before the normal retirement age are reduced actuarially.

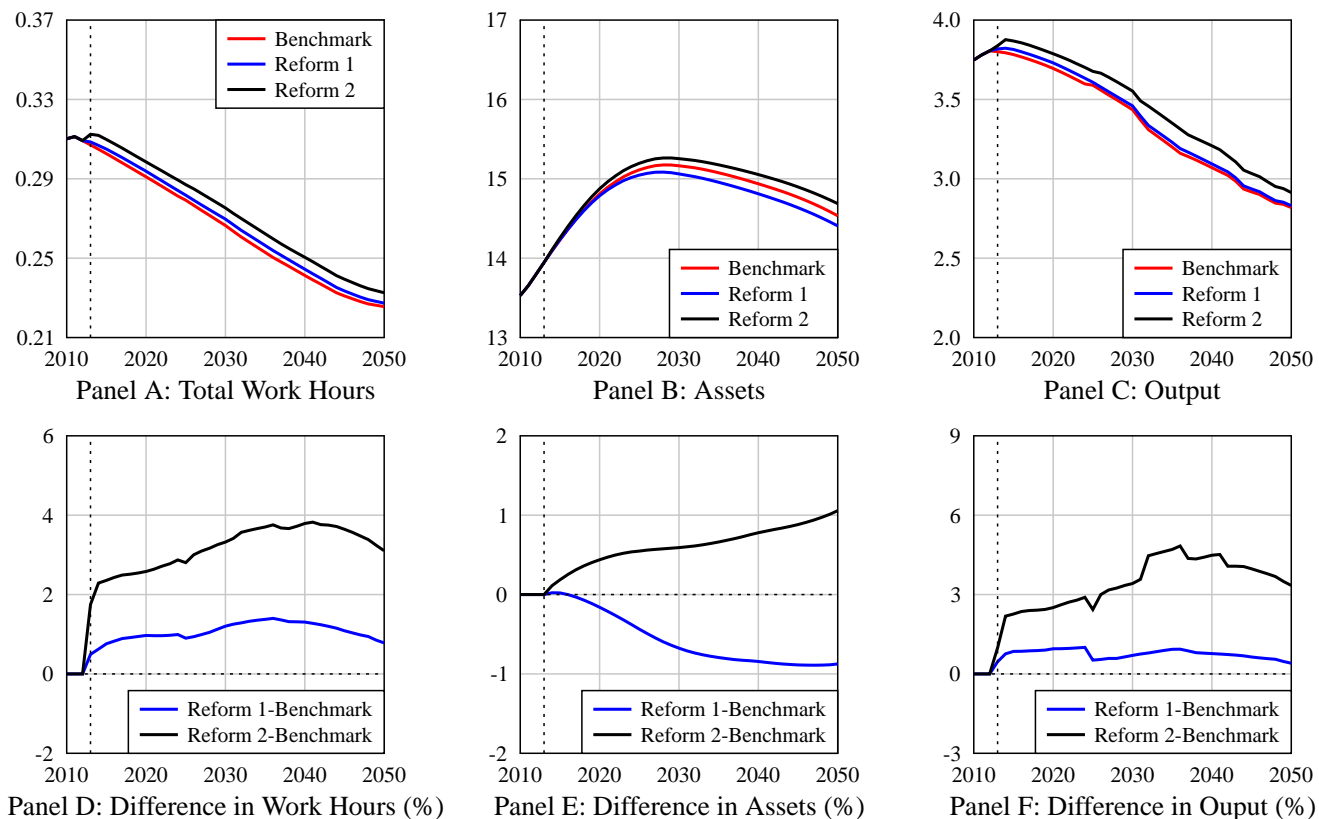
<sup>29</sup>This result is in part related to that of İmrohoroğlu and S. Kitao (2012), who found that raising the earliest retirement age by two years in the US leaves the social security budget balance unchanged



## 7.2 Efficiency

*Work hours.* Both reforms significantly increase the total work hours of those aged 60+ by 7.9 and 27.6 percent in 2050. The difference is accounted for by the fact that the first reform mainly affects the retirement behavior of dropouts, that is, those workers who make more use of the early retirement provisions. Regarding the total number of hours, the increases are 0.8 and 3.1 percent for that same year (see Panel D of Figure 6)<sup>30</sup>. A closer look at these figures reveals a reallocation of work hours during the working lifetime following the first reform. Specifically, middle-aged workers, particularly dropout workers, work less because they know that they will retire later and will collect higher social security benefits<sup>31</sup>.

Figure 6: Hours of Work, Assets, and Output



*Output.* The above results imply that the efficiency gains derived from these social security reforms are larger in the second reformed economy. For instance, in 2050, the first reform increases output by around 0.4 percent, but following the second reform, output is 3.3 percent higher that same year (see Panels C and F of Figure 6). Note, however, that we obtain that efficiency gains derived from the elimination of the early retirement scheme are small and distant from previous estimates. For example, Herbertsson and Orszag (2003) found that early retirement can be held responsible for a 5 to 7 percent reduction in the potential annual GDP in OECD countries, with these figures being higher for European countries. For the case of Spain, they found that the loss in output could be 9.3 and 11.1 percent in 2000 and 2010, respectively.

<sup>30</sup>Note that the benchmark model economy predicts that the change in the size and age distribution of the working age population could reduce total hours of work by 28 percent between 2010 and 2050 (see Panel A of Figure 6)

<sup>31</sup>These results are consistent with the findings of McGrattan and Rogerson (1998), who report that in the last century, workers in the US both shortened their working period and shifted work hours from older to younger ages, as social security coverage increased.

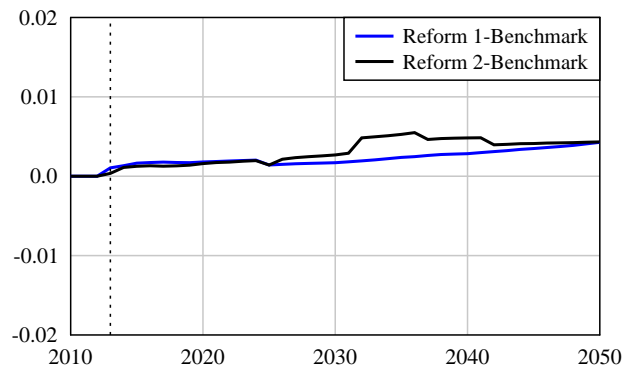
According to our results, however, there could be two reasons that tend to reduce the expected efficiency gains derived from the elimination of early retirement provisions. First, older workers supply less hours of work in comparison to their younger counterparts, as indicated by the decline in the profile of hours of work late in the life cycle<sup>32</sup>. Second, and as previously stated, because there may be some reallocation of work hours over the life cycle, that is, middle-aged workers may work less knowing that they will work until an older age<sup>33</sup>. Consequently, these two effects imply that lifetime and aggregate labor would change less following the abolition of early retirement provisions<sup>34</sup>.

Also, and differently from previous research papers, we find that the output gap may decrease in coming years despite the demographic transition. For instance, Herbertsson and Orszag (2003) found that the output lost due to early retirement schemes will increase in coming years because there will be more older workers. Contrarily, our results predict that this loss could decline during the next decades (see panel F of Figure 6) because the educational transition increases the share of the most educated workers. Specifically, this trend may affect retirement patterns since more educated workers may retire at a later age despite the fact that they value leisure to the same extent as less educated workers. This is due to the fact that the foregone labor income is higher for more productive individuals, who therefore find it more convenient to retire later. Hence, the participation rates of older workers increase and the output gap falls. For instance, and for the case of Spain, our model economy predicts that the average retirement age will increase from 63.7 years in 2010 to 65.0 years in 2050 due to the change in the educational composition of the Spanish population.

### 7.3 Inequality

*Income inequality.* We find that the above reforms bring no significant variation on income inequality (see Figure 7), since the Gini coefficient of total income is only 0.004 higher in both reformed model economies in 2050. This is due to two main reasons. First, because the three model economies have identical processes on the endowments of efficiency labor units. And second, because these reforms increase pension inequality only to a small degree as a result of the earnings dynamics at older ages.

Figure 7: Difference in the Gini Index of Total Income



<sup>32</sup>Empirical evidence shows that there are substantial cross-country differences in labor supply late in the life cycle. Erosa et al. (2011), for instance, found that government policies are behind such differences in the lower labor supply at older ages.

<sup>33</sup>Contrarily, Herbertsson and Orszag (2003) assumed that an increased labor supply of older workers, following the removal of the early retirement scheme, does not affect the labor supply of other workers.

<sup>34</sup>Similarly to Díaz-Saavedra (2012), we also find that both reforms change saving rates. After the elimination of the early retirement scheme, assets are almost 1 percent lower in the long run due to both the higher social security benefits and the shorter retirement period, as first conjectured by Feldstein (1974). Raising both legal retirement ages by two years increases the long-run assets by 1 percent because the cut in social security benefits induces households to supplement their retirement consumption by a combination of additional hours worked and saving.

Table 7: Individual and Aggregate Differences with The Benchmark Model Economy in 2050\*

	Actuarial reduction		No actuarial reduction	
	Reform 1	Reform 2	Reform 1	Reform 2
Social Security Sustainability				
Average Pension (%)	+2.5	-2.7	+4.0	-1.0
Average Ret. Age (years)	+0.6	+1.6	+3.3	+1.7
Social Security Deficit (%Y)	-0.3	-3.3	-3.4	-3.3
Efficiency				
Assets (%)	-0.9	+1.1	-3.4	+0.4
Work Hours (%)	+0.8	+3.1	+5.8	+3.1
Output (%)	+0.4	+3.3	+4.1	+3.2
Inequality				
Gini Income	+0.004	+0.004	0.005	+0.004

\* The table shows the effects of both reforms as the changes relative to the benchmark economy.

## 8 Sensitivity Analysis

There are two main features of the Spanish social security system that are not shared by many other retirement systems, especially in Europe. First, social security benefits taken before the normal retirement age are reduced actuarially as in the US and Canada. However, this is not the case in countries such as Germany, France, or Belgium. And second, the main component of Spanish social security benefits is based on the last 15 years of earnings before retirement. Other defined benefit retirement systems consider most of working life. Consequently, and to explore the robustness of our findings, we look at two other versions of the model economies that differ in the following features: first, we assume that benefits taken before the normal retirement age are not reduced actuarially; and second, we assume that the main component of social security benefits is based on labor earnings during most of working life. In each case, we continue to simulate the transitional dynamics for the three model economies.

### 8.1 No actuarial reduction in early benefits

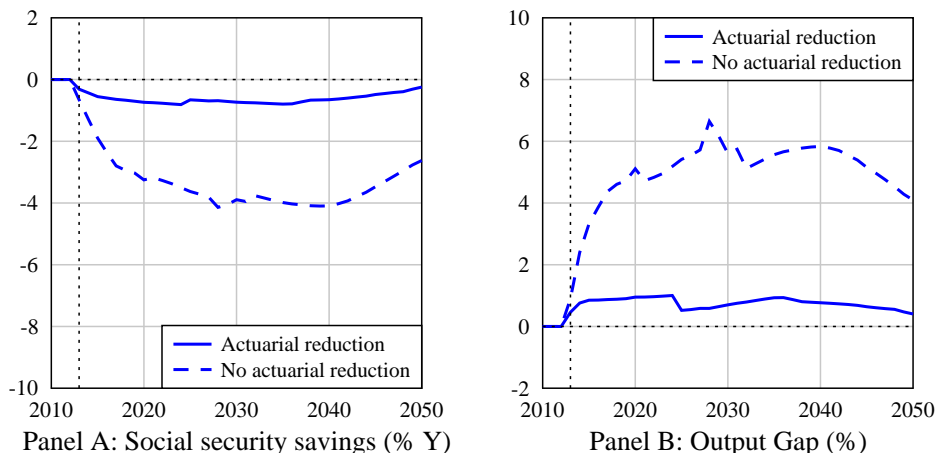
As previously described, social security benefits taken before the normal retirement age are reduced actuarially in the case of Spain. However, in many other European countries, there is little or no actuarial reduction. In Germany, for instance, a permanent reduction of 3.6 percent is applied to social security benefits for each year of early retirement before the normal retirement age of 65. This provides a very large incentive to leave the labor force early; in which case eliminating early retirement provisions could have larger fiscal and aggregate implications. To see this, we implement both previous social security reforms assuming that the penalties for early retirement are 3 percent for every year before the normal retirement age. This implies that workers who retire at the first retirement age of 60 collect 85 percent of the age-65 retirement benefit.

As expected, this type of reduction in early benefits changes the retirement behavior of older workers as a consequence of the enormous incentive to take benefits when they first become available. Specifically, the participation rate of all workers aged 60 to 64 in the benchmark model economy is 14.8 percent in 2010. Recall that this figure was 55.8 percent in that same period when we assumed an actuarial reduction for benefits taken early.

In Table 7 we present the main results of our new quantitative exercises. We find that the results arising from the second reformed economy resemble those obtained in our previous exercises. However, there are significant differences when we consider the elimination of the early retirement scheme. First, when social security benefits taken early are not reduced actuarially, a reform that eliminates early retirement provisions

significantly increases the average retirement age. According to our results, the average retirement age is 3.3 years higher in 2050 (see third block of Table 7). Consequently, the fiscal implications are significant since this reform initially reduces social security payments equivalent to around 1 percent of the benchmark economy output (see Panel A of Figure 8)<sup>35</sup>. In the long run, the amount saved by the social security system is 2.6 percent of the benchmark economy output.

Figure 8: Social Security Savings and Output Gap\*



\* Social security savings are measured as a percentage of output obtained in the benchmark economy.

Second, there is also a significant increase in total hours of work (see third block of Table 7), and hence in output. Figure 8 shows that the output gap reaches 6.8 percent in 2028, and then decreases during the following decades until reaching 4.1 percent in 2050. Panel B of Figure 8 also shows that these numbers are higher than those previously obtained in the model economy where early benefits were reduced actuarially. However, these numbers continue to be distant from previous estimates for countries where early benefits are not reduced actuarially. For instance, Herbertsson and Orszag (2003) found that the output gap in 2010 could be 17.9, 12.6, and 15.1 percent for Belgium, Germany, and France, respectively.

## 8.2 Longer averaging period

It can be argued that the averaging period used to compute social security benefits in Spain (the regulatory base) is too short<sup>36</sup>. For instance, the main component of social security benefits in the US is based on the 35 years of highest earnings. Similarly, social security benefits in Germany are mainly determined by average earnings during the entire working lifetime.

As a robustness check, it is interesting to analyze if our former results are also consistent with a social security scheme where benefits are computed using a longer averaging period. Consequently, we again carry out our three previous simulations, but now assuming that the social security scheme in our model economy uses a regulatory base given by the average earnings during the last 40 years before retirement. We find that the fiscal implications and the efficiency gains brought about by both reforms do not depend significantly on whether social security benefits are mainly determined by average earnings during most of the entire working lifetime.

<sup>35</sup>This number is consistent with the estimates from Gruber and Wise (2007) for countries where there is little or no actuarial reduction if benefits are taken early.

<sup>36</sup>Under the social security reform of 2011, this averaging period gradually increases from the last 15 years to the last 25 years before retirement.

## 9 Conclusions

To cope with the fiscal burden that aging populations pose on social security systems, many countries have increased their statutory retirement ages. At the same time, early retirement schemes are maintained despite claims that the trend to retire early could exacerbate both the fiscal challenge on the budget of social security systems and also the lost output.

This paper quantified the fiscal and efficiency consequences of the elimination of early retirement provisions, and compared them with those obtained from a two-year increase in both the age of early eligibility and the normal retirement age. We found that the relative performance of both reforms depends crucially on how early benefits are reduced in relation to benefits received at the normal retirement age. Our results predict that for those countries where early social security benefits are not reduced actuarially, the elimination of early retirement provisions will reduce future social security imbalances more and also increase output more. However, we also find that these efficiency gains derived from this reform are distant from previous estimates, and that they may decrease along the demographic transition if the workforce becomes more educated.

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## Appendix 1: Calibration of the Model Economy Ratios

### A1.1 Calibration of the Macroeconomic Ratios

- The Spanish National Income and Product Data reported by the *Instituto Nacional de Estadística* (INE) for 2010 are the following:

Table 8: Spanish GDP and its Components for 2010 at Current Market Prices

	Millon Euros	Shares of GDP (%)
Private Consumption	596,322	56.72
Public Consumption	221,715	21.08
Consumption of Non-Profits	10,589	1.00
Gross Capital Formation	244,987	23.30
Exports	283,936	27.00
Imports	306,207	29.12
Total (GDP)	1,051,342	100.00

- We adjust the amounts reported in Table 8 according to Cooley and Prescott (1995) and we obtain the following numbers:
  - Adjusted Private Consumption: Private Consumption – Private Consumption of Durables + Consumption of Non-Profits =  $596,322 - 54,127 + 10,589 = 552,784$  million euros.
  - Adjusted Public Consumption: Public Consumption = 221,715 million euros.
  - Adjusted Investment (Private and Public): Gross Capital Formation + Private Consumption of Durables =  $244,987 + 54,127 = 299,114$  million euros.
- The next adjustment is to allocate Net Exports to our measures of  $C$ ,  $I$ , and  $G$ . To that purpose, we compute the shares of each of those three variables in the sum of the three and we allocate Net Exports according to those shares. The sum of the three variables is 1,073,613 million euros and the shares of  $C$ ,  $I$ , and  $G$  are 51.49, 27.86, and 20.65 percent.
- Next we redefine the model economy's output and consumption from factor cost to market prices as follows:  $Y^* = Y + T_c$ , where  $Y^*$  is the model economy's output at market prices and  $T_c$  is the consumption tax collections, and  $C^* = C + T_c$ , where  $C^*$  is the model economy's consumption at market prices.
- Finally we use  $C^*/Y^* = 51.49$  and  $G/Y^* = 20.65$  as targets.

### A1.2 Calibration of the Government Policy Ratios

- In Table 9 we report the 2010 revenue and expenditure items of the consolidated Spanish public sector. Notice that the GDP share of Government consumption differs from the one that we have computed in Section A2.1 because here we use its unadjusted value.
- If we ignore the public pension system, the government budget in the model economy in 2010 is

$$G_{2010} + Z_{2010} = T_{c,2010} + T_{k,2010} + T_{y,2010} + E_{2010} \quad (35)$$



Table 9: Spanish Public Sector Expenditures and Revenues in 2010\*

Expenditures	Millions of euros	Percentage of GDP	Revenues	Millions of euros	Percentage of GDP
Consumption	221,715	21.08	Sales and gross receipts taxes <sup>a</sup>	94,234	8.96
Investment	40,091	3.81	Payroll taxes <sup>b</sup>	106,599	10.13
Pensions <sup>c</sup>	109,000	10.36	Individual income taxes	77,542	7.37
Other	108,839	10.35	Corporate profit taxes	19,425	1.84
			Other revenues	83,626	9.96
			Deficit	98,218	9.33
Total	479,645	45.62	Total	479,645	45.62

Source: Spanish National Institute of Statistics, Spanish Social Security, and Eurostat.

\*Shares of nominal GDP at market prices.

<sup>a</sup>It includes the tax collections from the Value Added Tax and other taxes on products.

<sup>b</sup>Total revenues from the Spanish Social Security.

<sup>c</sup>Total expenditure from the Spanish Social Security.

- Unintentional bequests,  $E_{2010}$ , are exogenous.
- We target the output shares of  $T_{c,2010}$ ,  $T_{k,2010}$ , and  $T_{y,2010}$ , so that they replicate the GDP shares of Sales and Gross Receipt Taxes, Corporate Profit Taxes, and Individual Income taxes.
- We have already targeted the output ratio of government consumption and we have already accounted for government investment.
- We define the output share of transfers other than pensions,  $Z_{2010}$ , residually to satisfy the budget.
- We report the model economy government budget items in Table 10 below.

Table 10: Model Economy Public Sector Expenditures and Revenues in 2010 (%Y\*Shares)

Expenditures		Revenues	
Consumption and Investment ( $G$ )	20.65	Consumption taxes ( $T_c$ )	8.96
Pensions ( $P$ )	10.35	Payroll taxes ( $T_s$ )	10.12
Other Transfers ( $Z$ )	0.83	Household income taxes ( $T_y$ )	7.66
		Capital Income Taxes ( $T_k$ )	1.84
		Unintentional Bequests ( $E$ )	3.25
Total	31.83	Total	31.83