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# On the Fiscal Balance of the Spanish Social Security System

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# On the Fiscal Balance of the Spanish Social Security System

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**Abstract**

We use a dynamic general equilibrium model with overlapping generations of agents who live for 65 periods in order to analyze the impact of the expected demographic changes in Spain on the fiscal balance of its social security system.

For that purpose, we calibrate the model to the Spanish economy and using alternative demographic scenarios we calculate the transition dynamics induced by these changes. Our main findings indicate that in the long-run the replacement rate will have to decrease by more than one half of its current value. During the transition this rate will reach even lower values around the period 2035-2055, mainly due to the fact that those cohorts who were born during the Baby-Boom will then be receiving pension benefits. The projected demographic dynamics have a large impact on the fiscal balance of the Spanish social security system and results vary significantly over time depending on the demographic scenario used.

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# 1 Introduction[1]

Demographic projections for OECD countries predict a change in the structure of the population in the medium and in the long run. This change basically consists of a decrease in both fertility and mortality rates that will bring about a considerable increase in the old-dependency ratio.[2]

Most OECD countries have a Pay-As-You-Go (PAYG) social security system, in which current workers, who pay the social security tax (contribution), finance the pension benefit of those retired in the same year. The greatest share of social security expenditure in these economies comes from contribution-related benefits. As a consequence, the ageing process of the population will induce a long-run financing problem for PAYG social security systems, with decreasing revenues and increasing expenditure, due to the greater number of inactive persons.

In the case of Spain, demographic projections show that, if the trend in the fertility and mortality rates remains constant, the potentially active population will remain close to stable until the early 2000s. The old-dependency ratio will increase progressively thereafter. From the year 2021 onwards, it will rise considerably due to the entry of the cohorts who were born in the fifties to early sixties, the so-called Baby-Boomers, into the group of people older than 65. This situation will become worse in the following years and will start to ease only towards the year 2050. Thus, demographic projections for Spain imply that in the medium and long run, there will be a sharp increase in the old-dependency ratio.

The Spanish social security system consists of two main regimes. The General Regime (*Régimen General*) involves privately employed workers and a part of the group of civil servants. The Special Regimes (*Regímenes Especiales*) involve self-employed workers, and some particular type of workers such as miners, farmers and fishermen. Total expenditure of the Spanish social security system amounted to 15.6 % of GDP in 1995 according to Levy

[1] This paper is based on the first chapter of the author's PhD dissertation, "A Dynamic General Equilibrium Analysis of the Spanish Social Security System" defended at the EUI in June 2000.

[2] The old-dependency ratio is defined as the ratio that relates the number of people aged 65 and more to those which are currently working.

(1995).[3] Expenditure in contribution-related benefits represented, for the same year, the greatest share in the total expenditure of the Spanish social security system, 57 %. Approximately 70 % of the total number of contributors belong to the General Regime. The General Regime also represents the highest share of expenditure on benefits, 63 %, as reported by Herce and Pérez-Díaz (1995). The revenues of this regime come from the compulsory social security payroll tax (28.3 % of wage in the late 1990s) which is shared by employees and employers. The General Regime is therefore, by far, the largest part of the system.

Retirement age is imposed at 65, but early retirement is permitted in special cases. The pension benefit is calculated as a function of the Regulatory Base (*Base Reguladora*). That is a certain percentage of a weighted average of the wage rate of the worker in the last 15 years, calculated according to standard predetermined rules. In order to receive a pension benefit equal to 100 % of the Regulatory Base, a replacement rate of 100 %,[4] the worker must have contributed to the system for more than 35 years. In order to receive any kind of pension the minimum length is 15 years.

In this paper we use a dynamic general equilibrium model with overlapping generations to examine the impact that the expected changes in the demographic structure will have on the Spanish social security system. We focus on the contribution-related benefits of the General Regime, which are a crucial element of the expenditure of the Spanish social security system, as described above.

The model in this paper incorporates an exogenous time-path for fertility change, as in Auerbach and Kotlikoff (1984), Auerbach and Kotlikoff (1987) and Auerbach, Kotlikoff, Hagemann and Nicoletti (1989). We also use time-varying conditional survival probabilities, as in De Nardi, İmrohoroğlu and Sargent (1999). The interaction of both factors (time-varying fertility and mortality) fully determine population dynamics. The demographic projections which are introduced exogenously into the model have been constructed from data provided by the Spanish Institute of Economics and Geography (IEG),

[3]This figure, reported from the Social Security budget, includes both expenditure on pensions and health services.

Total expenditure on social protection amounted to 21.5 % of GDP in 1995, according to the OECD Social Expenditure database (SOCX). This figure represented well over 50 % of total public expenditure for that very same year, in accordance with values reported from . Expenditure on old-age pensions (comprising old-age cash benefits solely) was 8.3 % of GDP.

[4]A replacement rate is defined as the value of a retirement benefit as a proportion of a worker's previous earnings for a specified period of years prior to retirement.

for both scenarios used.

The economy consists of overlapping generations of 65-period lived agents who face lifetime uncertainty, following the approach of Hubbard and Judd (1987) and İmrohoroğlu, İmrohoroğlu and Joines (1995). There is also a market for private annuities, as in Rios-Rull (1994, 1996) and Cubeddu (1996).

Agents retire after having worked for 45 years. From the mandatory retirement age until they die, at age $I$, they receive pension benefits. In order to finance those pension benefits, the government has established a social security contribution rate which approximates the rate payed in Spain for contribution-related retirement benefits. We depart from a situation, in the 1990s, where the agents receive a pension benefit that represents 100% of the average wage of the last fifteen years, as stipulated in the Spanish social security norms.

Our objective is to quantify, in a dynamic general equilibrium framework, given the conditions mentioned above, the necessary variations in the replacement rate in order for the fiscal balance to be met. For that purpose we use two different demographic scenarios, one with low fertility rates and one with high fertility rates. The model is calibrated to fit these demographic patterns and Spanish microeconomic evidence.[5]

The main findings are that the impact of the projected demographic changes on the fiscal balance of the social security system will be large, in line with the results obtained by several studies on the future viability of the Spanish social security system.[6]

[5]Examples of dynamic general equilibrium models designed for the study of the Spanish Economy in light of demographic variations include the work of Rios-Rull (1994), Rojas (1998) and Montero (1999). Rios-Rull (1994) and Rojas (1998) present general equilibrium models which focus on endogenous demographic change. Rios-Rull (1994) uses a large overlapping generations model to assess the effects on savings and interest rates of the demographic changes in Spain. In order to do so, he models fertility as a stochastic process subject to innovations. His probabilities of survival are time-invariant. Rojas (1998) uses a computable general equilibrium model with endogenous demographic change to assess the impact of the Spanish higher education policy on the social security system. Montero (1999) uses a large overlapping generations model to assess the steady-state implications of changing population growth rates in Spain on its social security system.

[6]The main contributions to this analysis are: Levy (1995), Herce, Pérez-Díaz et al. (1996), Barea, González-Páramo et al. (1996), MTSS (1996) and Piñera (1996), who use micro-simulation models, and Rios-Rull (1994), Rojas (1998) and Montero (1999) who use a general equilibrium framework.

Researchers have traditionally used micro-based simulation models constructed on the basis of projections of social security revenue and expenditure flows over time. The methodology underlying these studies is fairly similar. Using a simulation framework based on a macroeconomic scenario and demographic projections for the period under analysis, they

The paper is organized as follows. Section 1.2 describes the model economy. Section 1.3 states the calibration and parameterization procedures. Section 1.4 describes how we compute the equilibrium transition path. Section 1.5 summarizes the results. Finally, section 1.6 concludes.

# 2 The Model

The economy is a 65-period overlapping generations model based on Auerbach and Kotlikoff (1987), with the following features that depart from their model:

1. Agents face lifetime uncertainty, i.e. non-unitary survival probabilities, following the approach suggested by Hubbard and Judd (1987) and İmrohoroğlu, İmrohoroğlu and Joines (1995).
2. There exists a market for private annuities, in which agents can insure against mortality risk, as in Rios-Rull (1994, 1996) and Cubeddu (1996).
3. We use time-varying probabilities of survival, together with time-varying population birth rates. This approach is similar to the one presented in De Nardi, İmrohoroğlu and Sargent (1999).[7]

There is a single consumption good. The economy consists of overlapping generations of agents who live for a maximum of $I$ periods, after which death is certain, where ages will be denoted by subindex $i \in \mathcal{I} \equiv \{1, ..., I\}$. Time will be denoted by subindex $t$, $t \in \mathcal{T} \equiv \{1, ..., T\}$. Agents belonging to the same generation are identical.

At time $t$, agents face a probability of surviving between age $i$ and age $i + 1$, which is denoted by $s_{t,i}$, being $s_{t,I} = 0$. The unconditional probability

aim either at quantifying the evolution of the deficit of the system over time (see, for instance, Barea, González-Páramo et al.(1996)), or the necessary increases in the contribution rates in order for the system to keep its fiscal balance (see Levy (1995)). Depending on the different macroeconomic scenarios and demographic projections used, the outcomes obtained are fairly different (see Table 1 in Appendix I for a summary of the main results of these studies for the Spanish social security system). All studies spot with no exception a financial problem for the Spanish social security system in the medium-run (in the neighbourhood of years 2020-2025).

[7]Using time-varying probabilities of survival, the authors derive the birth rates which correspond to the forecasts of the dependency ratio given by the U.S. Social Security Administration.

of reaching age $i$ is therefore $s_t^i = \prod_{k=1}^{i} s_{t-k,i-k}$. The age distribution of the population for a given year, $t$, is denoted by $\left\{\mu_{t,i}\right\}_{i\in\mathcal{I}}$.

At a date $t$, a cohort of new workers is born. Let $\mu_{t,i}$ denote the number of people of age $i$ alive at time $t$, and let $n_t$ be the rate of growth of new agents. The following law of motion holds:

$$\mu_{t+1,i+1} = s_{t,i}\,\mu_{t,i}$$

while for newborn agents:

$$\mu_{t,1} = (1+n_t)\ \mu_{t-1,1}$$

Let $\eta_t = \prod_{k=1}^{t}(1+n_k)$. Then, as shown by De Nardi, İmrohoroğlu and Sargent (1999), the fraction of people of age $i$ alive at time $t$ is:

$$\Psi_{t,i} = \frac{s_t^i\,\eta_t}{\sum_{k=1}^{I} s_k^i\,\eta_{t-k}}$$

We take the paths $\{n_t\}^{t\in\mathcal{T}}$ and $\{s_{t,i}\}_{i\in\mathcal{I}}^{t\in\mathcal{T}}$ as parameters.

## 2.1 Preferences

Agents in the economy derive their utility from consumption and leisure. Each agent is assumed to have preferences which can be represented by the following discounted utility function:

$$\sum_{i=1}^{I} \beta^{i-1}\, s_{t'}^i\ u\left(c_{t',i}, x_{t',i}\right) \tag{1}$$

$c_{t',i}$ stands for consumption in period $t' = t+i-1$ of an age $i$ agent born in $t$. Correspondingly, $x_{t',i}$ stands for leisure ($l_{t',i}$ stands for labour supply), and $\beta$ is the subjective discount factor.

The budget constraint of an age $i$ agent in period $t$ is as follows:

$$
\begin{aligned}
c_{t',i} + y_{t',i} &= (1 + r_{t'})\; a_{t',i} + \Omega_{t'} & (2)\\
\text{where } \Omega_{t'} &= \begin{cases} w_{t'}(1-\tau_{t'})\,\varepsilon_i\, l_{t',i} & \text{if } i \le I_R \\ b_{t'} & \text{if } i > I_R \end{cases} \\
a_{t'+1,i+1} &= \frac{y_{t',i}}{s_{t',i}} & (3)\\
a_{t,1},\, a_{t,I+1} &= 0
\end{aligned}
$$

where, for an individual of age $i$, $a_{t',i}$ stands for the asset holdings (accumulated net wealth), $a_{t'+1,i+1}$ is next period's asset holdings, $y_{t',i} = a_{t'+1,i+1}\, s_{t',i}$ is gross savings, $\tau_{t'}$ stands for the social security payroll tax and $b_{t'}$ for the retirement benefit.

A unit of time for an agent aged $i$, can be transformed into one unit of leisure or $\varepsilon_i$ exogenous age-specific efficiency units of labour input, as in Auerbach and Kotlikoff (1987). The gross interest rate is $R_{t'} = (1 + r_{t'})$ and the real wage rate per efficiency unit of labour in terms of the consumption good is $w_{t'}$.

Agents are endowed with one unit of time, which they allocate to leisure or labour. They choose how much labour to supply between age 1 and age $I_R$ and must retire and supply no labour thereafter, relying exclusively on private savings and social security benefits in order to finance their consumption.

We also impose, as in Auerbach and Kotlikoff (1987), a non-negativity constraint on the labour supply decision, i.e. if the agent were to demand more than one unit of leisure in a given period, the individual would have to retire and supply no labour. This is represented by the following constraint:

$$
l_{t',i} > 0 \tag{4}
$$

In each period agents receive capital income, $(1+r_{t'})\; a_{t',i}$, and alternatively labour income (if $i \le I_R$), $w_{t'}(1-\tau_{t'})\varepsilon_i\, l_{t',i}$ or retirement benefit (if $i > I_R$), $b_{t'}$, and they decide how much to allocate to savings, $y_{t',i}$, and leisure, $x_{t',i}$, on the basis of the life cycle model of behavior. Agents accumulate assets to smooth their consumption over time.

Individuals insure against mortality risk because there exists a market for private annuities. Here, as in Rios-Rull (1994), it is assumed that agents of the same age cohort sign a contract stipulating that survivors will share the assets (or debts) of agents that die so that the next period's asset holdings (debts) are this period's savings (borrowings) divided by the probability of surviving. The existence of the annuities market is represented by constraint (2.1). Agents are born with zero non-human wealth, $a_{t,1} = 0$ and leave no intended bequests, $a_{t,I+1} = 0$.

Notice that with this specification of (1.2) any liquidity constraint is disregarded and households can borrow against lifetime income, including retirement benefits, at the going market rate of interest.

## 2.2 Technology

The economy produces a single good from aggregate capital and labour according to a standard constant returns to scale production function:

$$Y_t = f\ (K_t,\, L_t) \tag{5}$$

where $K_t$ is the aggregate capital stock and $L_t$ is the aggregate labour input. Output can be used for consumption in the same period as production takes place or it can be used for increasing next period's capital stock. Capital depreciates at rate $\delta$. Aggregate output is represented by $Y_t$.

Firms hire physical capital and effective labour until factor prices equal marginal products:

$$r_t = f_K\,(K_t,\, L_t) - \delta \tag{6}$$
$$w_t = f_L\,(K_t,\, L_t) \tag{7}$$

## 2.3 Social Security System

There is a government in the model which manages the retirement insurance program. The government collects the social security payroll tax and makes the corresponding transfers in the form of retirement benefits to the agents once they retire. This retirement insurance program adopts the form of a publicly administered pure PAYG system. This implies that government revenue must equal government expenditure in every period.

In this system, agents contribute a certain percentage of their income ($\tau_{t'}\, \varepsilon_i\, w_{t'}\, l_{t',i}$) to the system during $I_R$ years of working time. Government's revenue from taxation is therefore given by:

$$T_t = \tau_t \, w_t \sum_{i=1}^{I_R} \mu_{t,i} \, \varepsilon_i \, l_{t,i} \tag{8}$$

After their retirement, for $i \in [I_R + 1, ..., I]$, agents receive benefits according to the following formula:

$$b_t = T_t \left( \sum_{i=I_R+1}^{I} \mu_{t,i} \right)^{-1} \tag{9}$$

Define average earnings over the last $f$ years of the working life of an age $i \in [I_R + 1, I]$ agent, born in $t$, as:

$$z_t = \frac{1}{f} \sum_{i=I_R+1-f}^{I_R} \varepsilon_i \, l_{t',i} \, w_{t'} \tag{10}$$

The replacement rate is then defined as:

$$\rho_t = \frac{b_t}{z_t} \tag{11}$$

Total expenditure in retirement benefits is therefore:

$$G_t = \sum_{i=I_R+1}^{I} \mu_{t,i} \, b_t \tag{12}$$

The budget constraint of the government is therefore balanced period by period:

$$T_t = G_t \tag{13}$$

## 2.4 Equilibrium

In this economy, the only exogenous source of variation from year to year comes from changes in the demographic structure of the population.

A competitive equilibrium for this economy is a sequence of individual allocations, $\{c_{t',i}\}_{i \in \mathcal{I}}$, $\{x_{t',i}\}_{i \in \mathcal{I}}$; asset holdings $\{a_{t',i}\}_{i \in \mathcal{I}}$; aggregate inputs $\{K_t, L_t\}$ ; and a set of factor prices $\{r_t, w_t\}$, such that for all $t$:

1. All agents maximize (1.1) subject to (1.2).

2. Prices are competitively determined, i.e. firms maximize profits, so that factor prices equal the marginal productivities of the factors of production as in (1.6) and (1.7).

3. Factor markets clear:

$$L_t = \sum_{i=1}^{I_R} \mu_{t,i}\, \varepsilon_i\, l_{t,i} \tag{14}$$

$$K_t = \sum_{i=1}^{I} \mu_{t-1,i}\, a_{t-1,i} \tag{15}$$

4. Goods market clears, so the following feasibility condition is satisfied:

$$\sum_{i=1}^{I} \mu_{t,i}\, (c_{t,i} + a_{t,i}) = f\left(K_t,\, (1+\lambda_y)^t\, L_t\right) + (1-\delta) \sum_{i=1}^{I} \mu_{t-1,i}\, a_{t-1,i} \tag{16}$$

   which in aggregate terms can be rewritten as:

$$Y_t = C_t + K_{t+1} - (1-\delta)\, K_t = C_t + I_t$$

   where $C_t$ stands for aggregate consumption and $I_t$ for aggregate investment.

5. The period by period budget constraint of the government satisfies (1.13).

A steady state for this economy is an equilibrium that does not change over time and which consists of a pair of factor prices for capital and labour, $\{r, w\}$; age profiles for consumption, leisure and assets, $\{c_i, x_i, a_i\}_{i\in\mathcal{I}}$; and aggregate inputs $\{K, L\}$.

# 3 Parameterization and Calibration of the Model

In the model, agents are born into adulthood at age 21 and can live up to age 85, after which death is certain. They supply labour until retirement age, which is imposed at age 65. This implies that $I_R = 45$ and $I = 65$.

## 3.1 Transition Demographics

### 3.1.1 Projections[8]

We use two alternative demographic scenarios which differ in the underlying hypothesis about mortality (life expectancy) and fertility (average number of children per woman) patterns. These scenarios can be described as follows:

(1) Scenario I: *High fertility rates.* The average number of children per woman departs from a value of 1.17 in 1995 and grows at a yearly rate of around 3 % until year 2012 , when it starts to decline, reaching a level of 1.8 in year 2025.

(2) Scenario II: *Low fertility rates.* The average number of children per woman departs from a value of 1.17 in 1995 and grows at a yearly rate of around 2 % until year 2009, when it slows down, reaching a level of 1.6 in year 2025.

In both cases:

- The average number of children per woman is kept constant from year 2026 onwards (see Figure A1 in Appendix II).
- Life expectancy increases progressively with a declining rate, from a starting value of 81.16 years for women and 74.13 for men, in 1995. For year 2051, these values have gone up to 84.65 and 78.21, respectively (see Figure A2 Appendix II).
- The rates of growth of new workers (birth rates), $n_t$, and the probabilities of survival, $s_{t,i}$, are derived (for the total population, i.e. men and women jointly) from these demographic projections[9].

### 3.1.2 Calibrated Transition

Our initial conditions are obtained by computing and calibrating an initial steady state using constant pre-1995 values of the demographic parameters,

[8] The original projections for the period 1995−2051 were kindly provided by Juan Antonio Fernández Cordón, of the Spanish Institute of Economics and Geography (*Spanish Council for Scientific Research, CSIC).*

[9] In order to generate these projections, migration flows have not been considered.

$n_0$ and $s_{0,i}$. Then, in order to compute the transition path, we take time-varying parameters, $\{n_t\}^{t\in\mathcal{T}}$ and $\{s_{t,i}\}_{i\in\mathcal{I}}^{t\in\mathcal{T}}$, obtained from the demographic projections.[10]

The underlying methodology (based on the De Nardi, Imrohoroglu and Sargent (1999) technique) amounts to calibrating the rates of growth of the model population to match the Life Tables and the path of the dependency ratio embedded in the IEG projections.

Those demographic projections have been extended into the future up to year 2150, assuming a constant population growth rate for the period $2052-2150$ equal to the IEG average growth rate during the period $1995-2051$.

When life expectancy stabilizes in year 2051, the demographic structure of the population will still adjust for $I+1$ years, such that a new steady state is reached in period $2051+(I+1)$, where it will be essentially equal to its long-run structure (see Figure 2 below).

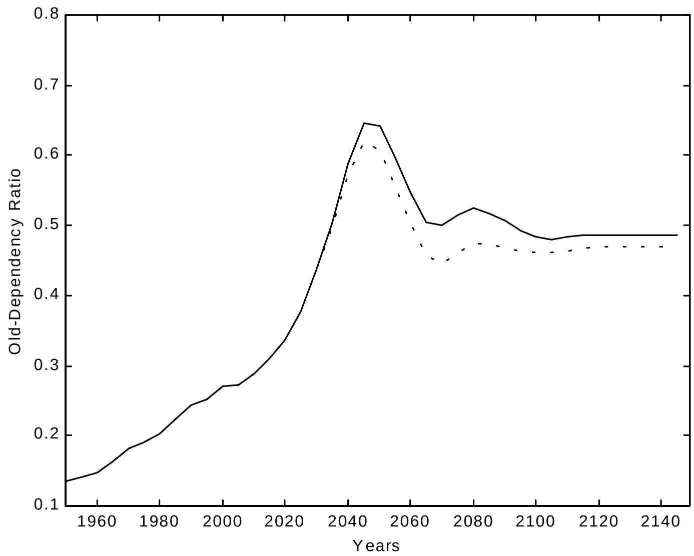


Figure 2: Projected Old-Dependency Ratio over the Period 1950-2150 (continuous line: Scenario I; dotted line: Scenario II).

[10] As in De Nardi, Imrohoroglu and Sargent (1999), we assume that prior to 1995, the economy was in a steady state and agents were experiencing the survival probabilities of the 1995 IEG life table. In 1995, they suddenly realize that the tables are changing over time and switch to using the correct ones. The IEG Life Tables at our disposal run only until year 2051. From that year onwards, it is assumed that the age distribution of the probabilities of survival is equal to the one in 2051.

In the figure above, we have plotted the old-dependency ratio[11]. It can be observed that the ratio is higher for Scenario II, and that the gap between the two ratios is narrower, the further in time.

As in De Nardi, İmrohoroğlu and Sargent (1999), it is the departure of the demographic parameters from their initial values that requires fiscal adjustments to be made in the social security system.

## 3.2 Preferences

The utility function is parameterized as:

$$u\left(c_{t',i}, x_{t',i}\right) = \frac{1}{1-\sigma}\left(c_{t',i}^{\alpha}\, x_{t',i}^{1-\alpha}\right)^{1-\sigma} \tag{17}$$

so that it is of the constant relative risk aversion class (CRRA).

The consumer's problem is therefore the maximization of (1.1) subject to (1.2). From the first order conditions of that problem we can derive the transition equations for consumption and leisure.

In order to calibrate preferences, the parameters $\beta$ and $\sigma$ must be chosen. We do so by using the transition equation in consumption. By setting the growth rate of consumption and the real interest rate to their mean over the last two decades, and fixing $\beta$ to its calibrated value, we obtain a value of $\sigma$ of around 4. We choose $\sigma = 4$, in accordance with the value selected by Rios-Rull (1994). We set the parameter $\alpha$, governing the trade-off between consumption and leisure, to 0.33, such that agents under 65 devote, on average, around one third of their time to market work. We set the discount factor to $\beta = 0.985$, as in Auerbach and Kotlikoff (1987).

## 3.3 Technology

The economy produces a single good from aggregate capital and labour according to a Cobb-Douglas production function:

$$Y_t = f\left(K_t^d, L_t^d\right) = A\left(K_t^d\right)^{\theta}\left(L_t^d\right)^{1-\theta} \tag{18}$$

[11] We have extended the IEG projections into the past making use of the estimates provided in the United Nations publication "World Population Prospects 1950-2050 (The 1998 Revision)" and its corresponding dataset.

$A$ is a scaling constant and $\theta$ is a parameter which measures the capital share in income.

The empirical evidence that factor shares and capital-output ratios have remained roughly constant over time (see Licandro et al. (1995)) while the ratio $\frac{w}{r}$ has increased suggests the use of this functional specification.

The problem of the representative firm is therefore:

$$\max_{K_t^d,\, L_t^d} A\left(K_t^d\right)^{\theta}\left(L_t^d\right)^{1-\theta} - w_t\, L_t^d - (r_t + \delta)\, K_t^d \tag{19}$$

In equilibrium, factor markets clear so that labour demand equals labour supply, $L_t^d = L_t^s$, and capital supply equals capital demand, $K_t^d = K_t^s$. Firms maximize profits taking factor and output prices as given. They hire physical capital and labour until factor prices equal marginal products, so that:

$$r_t = A\theta\left(\frac{K_t}{L_t}\right)^{\theta-1} - \delta \tag{20}$$

$$w_t = A(1-\theta)\left(\frac{K_t}{L_t}\right)^{\theta} \tag{21}$$

In order to calibrate the production function we need the values for the following parameters: $A$, $\theta$, $\delta$ and $\varepsilon$:

*Production function constant*: The choice of the scaling parameter representing total factor productivity, $A$, depends on the units chosen for output. It is set to be constant so that the wage rate per one-year adult is exactly 1.0 for the initial steady state. This requires a value of $A = 0.95$.

*Capital intensity parameter*: For a Cobb-Douglas production function, this parameter represents the share of capital in income. The historical share of capital in national income in the National Accounts suggests a value of 0.5. Ríos-Rull (1994) and Bailén and Gil (1996), among others, consider that this value is far too high because labour income in the National Accounts excludes a part of the income of self-employed workers which is in turn included in capital income. We will choose a value of 0.35 for the parameter $\theta$.

*Depreciation rate*: The rate of depreciation in the National Accounts is around 10 % of output. We have chosen the value of $\delta$ such that the initial steady state capital-output ratio (in the 1990s) matches the one of the Spanish economy. This is the procedure in standard literature on overlapping generations. For a value of the capital-output ratio reported by King and Levine (1994) to be 2.65, the parameter $\delta$ is set to 7.5 %.

*Efficiency units profile*: This profile is exogenous and age-specific, as in Auerbach and Kotlikoff (1987). It determines relative wages by age. We have chosen a profile derived from data obtained in the Encuesta Sobre Conciencia y Biografía de Clase of the National Statistics Institute (Instituto Nacional de Estadística, 1991) and smoothed it by fitting a polynomial of order two to the data.

The efficiency units profile is plotted in Figure A3 (Appendix II). The resulting profile is in line with the findings of Hansen (1993). That figure has the clear implication that workers with higher work experience achieve a higher efficiency level. Wages double between ages 21 and 40 and from then onwards they do not alter widely until retirement age.

### 3.4 Social Security System

For each demographic scenario presented, we pick the social security payroll tax, $\tau_t$, so that it reproduces the actual level in the economy. Social security payroll tax was 28.3 % in the late 1990s. The revenue from this tax finances not only the retirement benefit but also other benefits such as the disability or the survivors benefits. We have estimated the actual percentage which is used to finance the retirement benefit as 70 % of that tax rate.[12] So, we set a constant social security payroll tax rate, $\tau_t = 0.195$.

The parameter $f$, in equation (1.10), which represents the number of periods involved in the rule which is used to calculate pension benefits, is set to 15, as in the current system.

## 4 Computation

Our computational strategy amounts to solving: (1) the initial steady state (ISS) of the economy, (2) the final steady state (FSS) of the economy, and (3) the transition path the economy follows between these two steady states. The

[12] Herce and Pérez Díaz (1995) estimate this percentage to be 80 %. A similar percentage, of around 70 %, can be obtained from the social security data presented in Levy (1995).

evolution of the transition demographics from the values at the initial steady state requires fiscal adjustments to be made. Perfect foresight is assumed in order to calculate the transition path and the steady states.

As there is no detailed data available on individual asset holdings by age cohort, we must approximate the initial asset distribution. From the set of available options (see Rios-Rull (1994)), we choose to calibrate a set of parameters so that the initial steady state matches the main characteristics of the Spanish economy in the nineties. We then take this outcome as the initial conditions[13].

In order to find the initial and final *steady state* equilibria of the model, for a given social security system, we must solve a complicated set of nonlinear equations that specify the optimization behaviours of individual agents, firms and government. For that purpose, we use the Gauss-Seidel iterative method proposed by Auerbach and Kotlikoff (1987). The algorithm starts with guesses about one of the endogenous variables of the model. This makes the system easier to solve for the endogenous variables, including the one for which the guess was made. When the solution for this initially guessed endogenous variable equals the guess itself, a true solution to the system is found. Otherwise a new guess which is obtained as a combination of the two sets of values from the previous iteration must be tried. The procedure is repeated until the true solution is found.

For a given efficiency units age profile, $\{\varepsilon_i\}_{i\in I}$ and evolution of the demographic parameters, $\{n_t\}^{t\in\mathcal{T}}$ and $\{s_{t,i}\}_{i\in I}^{t\in\mathcal{T}}$, the steps involved in this procedure are the following:

1. Initialize the aggregate capital stock of the economy, $K^0$, as the sum of an initially guessed asset holdings distribution, using (1.15). Initialize the aggregate labour input, $L^0$, as the sum of an initial guessed labour supply vector, using (1.14).

2. Given $K^0$ and $L^0$, solve the problem of the firm, (1.19), and use the marginal conditions, (1.20) and (1.21), in order to obtain the factor prices, $r_0$ and $w_0$.

[13]For an alternative approach, see Rios-Rull (1994), where the author presents a version of a large overlapping generations model with a procedure to generate initial conditions for the distribution of wealth by age groups. In order to do so, he models demographic dynamics with the aid of univariate stochastic processes. The model is simulated until the age distribution of the population resembles the one of the current economy.

3. Given the pair $\{r_0, w_0\}$, the level of social security payroll tax, $\tau$, and the shadow wages, solve the problem of the agent, (1.1) s.t. (1.2), and obtain a sequence for the asset holdings, $\{a_{i,0}\}_{i\in I}$, and consumption, $\{c_{i,0}\}_{i\in I}$.

4. The aggregation of individual labour supply decisions, according to (1.14), gives us a new estimate of the total supply of labour, $L^1$. We also obtain a new value for the aggregate capital stock $K^1$, using (1.15).

5. Specify a convergence criterion such that, if the new aggregate capital stock is close enough to the old one, $K^1 \simeq K^0$, the algorithm stops. Otherwise, the initial condition is updated and the procedure is repeated until convergence is achieved.

The *transition* path is solved using a similar method to the one used to calculate the initial and final steady states. However, as the situation in the economy changes from period to period, it is necessary to solve explicitly for the behaviour of the agent in each of the periods. Furthermore, the fact that agents take into account the future stream of prices implies that it is necessary to solve simultaneously for equilibrium in all the transition years.

In order to do so, we allow the economy 150 years to adjust, i.e. to move from the initial to the final steady state[14]. Here we also use a Gauss-Seidel iterative method but the dimension of the problem, and hence the computational load, is increased by a factor equal to the number of transition periods (i.e. 150). It should be emphasized that, up to the time the demographics change, individuals born before the transition starts behave as if the initial steady state would continue forever. At the time the transition starts, these individuals behave as if they were members of a new generation.

# 5 Results

This section contains the simulation results of our calibrated model for the two different demographic scenarios. The path of demographic change has major impacts on the outcome of the model. The following table compares the long-run social security responses to the demographic transition in both scenarios.

[14] This is intended to provide the economy with enough time to settle down before it is forced to converge after the 150 period have passed, as in Auerbach and Kotlikoff (1987).

**Long-Run Responses under alternative Demographic Scenarios**

| | *ISS* | *Long-Run (I)* | $\Delta\nabla$ (%) | *Long-Run (II)* | $\Delta\nabla$ (%) |
|---|---|---|---|---|---|
| $r$ | 5.90 | 3.98 | -32.5 | 3.73 | -36.8 |
| $w$ | 1.00 | 1.09 | 8.7 | 1.11 | 9.9 |
| $b$ | 0.33 | 0.22 | -34.5 | 0.20 | -39.5 |
| $\rho$ | 1.00 | 0.47 | -53.6 | 0.42 | -58.6 |
| $C/Y$ | 0.80 | 0.78 | -3.0 | 0.77 | -3.3 |
| $I/Y$ | 0.20 | 0.22 | 12.2 | 0.23 | 13.4 |
| $K/Y$ | 2.66 | 2.99 | 12.2 | 3.02 | 13.4 |
| $K/L$ | 4.02 | 5.18 | 28.8 | 5.39 | 34.0 |

The long-run effects of the demographic changes are as follows:

**(Scenario I: High Fertility Rates)** The pension benefit decreases by 34.5%, and the replacement rate lowers by 53.6%. The interest rates fall from 5.90% to 3.98%, while wages rise from 1.00 to 1.09. The consumption-output ratio lowers by 3%, with a corresponding change in the investment-output ratio, which rises by 12%. The capital-output ratio increases from 2.65 to 2.89 and the capital-labour ratio rises from 4.02 to 5.18.

**(Scenario II: Low Fertility Rates)** The pension benefit decreases by 39.5%, and the replacement rate does so by 58.6%. The interest rates fall from 5.90% to 3.73%, while wages rise from 1.00 to 1.11. The consumption-output ratio lowers by 3.3% with a corresponding change in the investment-output ratio, which increases by 13.4%. The capital-output ratio increases from 2.65 to 3.02 and the capital-labour ratio increases from 4.02 to 5.39.

Throughout the transition path, especially during the period 2035-2055, the effects are greater, reaching values of up to 28.9% (Scenario I) and 27.3% (Scenario II) for the replacement rate, when the generations belonging to the Baby-Boom are receiving pension benefits.

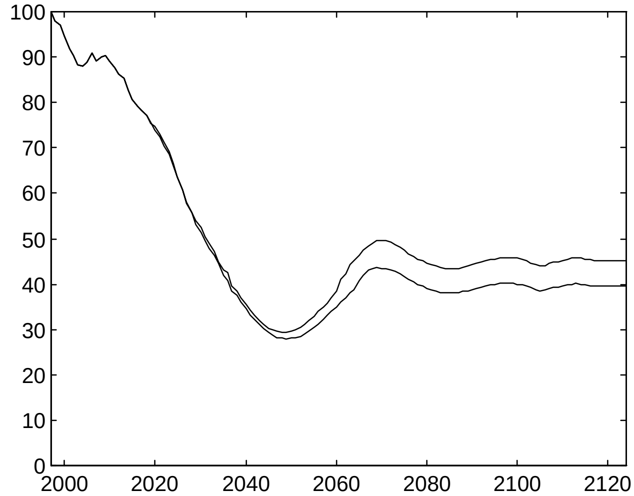


Figure 3: Evolution of the Replacement Ratio during the Transition (upper line represents Scenario I; lower line stands for Scenario II).

The effects will be larger for Scenario II (low fertility rates) than for Scenario I (high fertility rates). Indeed, for Scenario II, the required long-run fall in the replacement rate, in order to meet the fiscal balance requirement, is 9.3% greater than for Scenario I, in the long-run.

For both scenarios, the results are such that in the long-run wages rise and interest rates fall in response to the increase in capital per worker, as a result of the decrease in the share of young workers, who own relatively little wealth. Both the capital-output ratio and capital-labour ratio rise. The effects of the demographic dynamics are such that a large social security adjustment will have to take place in order for the fiscal balance to be met.

# 6 Conclusions

The projected demographic dynamics will have a large impact on the fiscal balance of the Spanish social security system. Our results point out that the replacement rate should reduce by more than one half of its present value in order for the social security system to keep its fiscal balance in the long-run. During the transition period, this ratio would have to attain even lower values.

Our framework could be easily extended towards the study of the necessary increases in the social security contribution rate, in order for the social security system to meet its fiscal balance over time with the aim of analyzing the effects on labour supply stemming from variations in the contribution rates. It would then be possible to compare the effects that these variations generate on the intergenerational redistribution of welfare, with the examined policy of reducing the replacement rate, in light of the demographic transition.

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# Appendix I: Tables

*Table 1*: Macroeconomic Scenarios and Main Results of Cited Studies

| | FEDEA 1995-2025 | MTSS 1996-2010 | Levy* 1995-2050 | Piñera 1995-2025 | BBV 1993-2020 | |
|---|---|---|---|---|---|---|
| **Growth (in %):** | | | | | | |
| Employment | 1.0 | 0.9 | 1/-1.5 | 0.7 | 0.7 | |
| GDP | 2.5 | 2/2.5 | 2.5 | 2.5/3.5 | 3 | |
| Productivity | 1.5 | 1.1/1.6 | 1.4 | – | 2.5 | |
| Real Wages | 1.3 | 1.2 | 1.4 | 1.2 | 1.6 | |
| No. Pensions | 1.4 | 1.1 | 2.2 | 1.5 | 1.0 | |
| Avg. Pension | 1.2 | 2.0 | – | 1.9 | 1.6 | |
| **Deficit (%GDP):** | | | | | | |
| 1995 | 2.2 | -0.26 | 0 | -0.1 | 0.8 | (1993) |
| 2010 | 2.9 | 0.1/1.7 | 0 | 1.4 | 1.7 | (2005) |
| 2025 | 3.5 | – | 0 | 4.0 | 1.8 | (2020) |
| *** Average contribution rate to finance pensions (2000=100):** | | | | | | |
| 2010 | | | 110/120 | | | |
| 2030 | | | 150/180 | | | |
| 2050 | | | 150/210 | | | |

Source: Cited Studies and Jimeno & Licandro (1996).

# Appendix II: Graphs

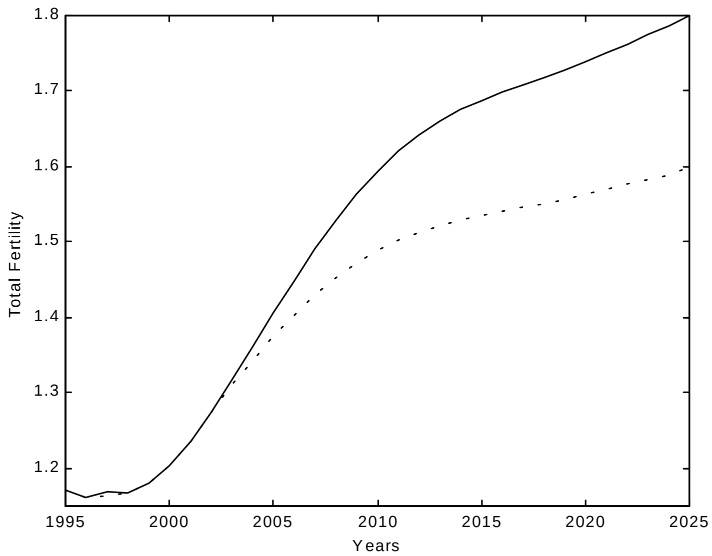


Figure A1: Projected Total Fertility (Average Number of Children per Woman), 1995-2025 (upper line: Scenario I; lower line: Scenario II).

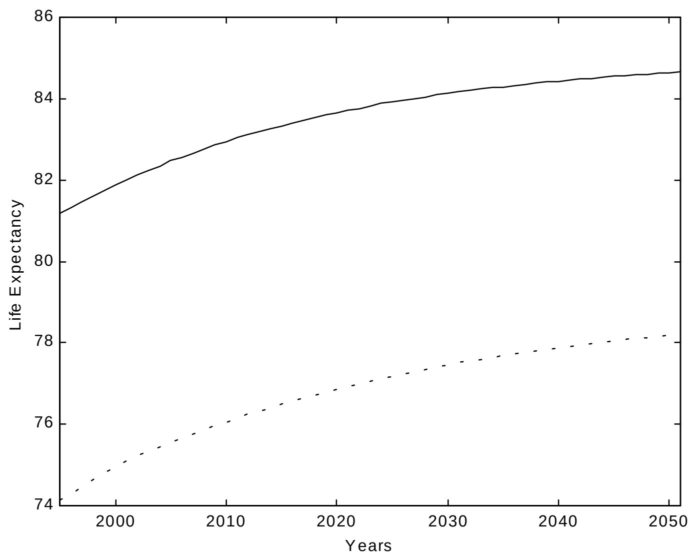


Figure A2: Projected Life Expectancy in Spain, 1995-2051 (for women: continuous line; for men: dotted line).

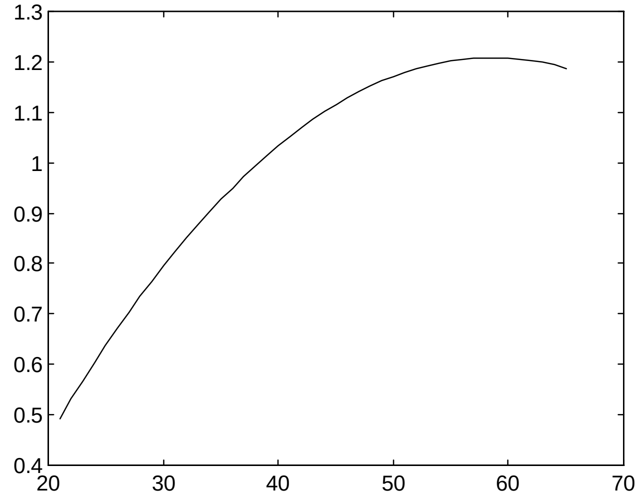


Figure A3: Smoothed Efficiency Units Profile.

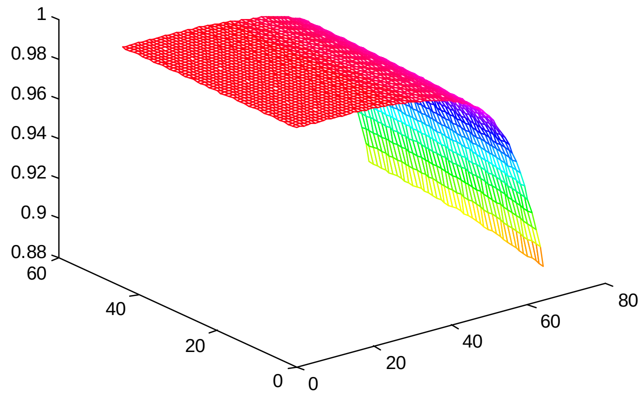


Figure A4: Simple Probabilities of Survival for the period $1995 - 2051$ (on the $x$-axis: age of the agents; on the $y$-axis: period $1995 - 2051$; and on the $z$-axis: values of the probabilities).

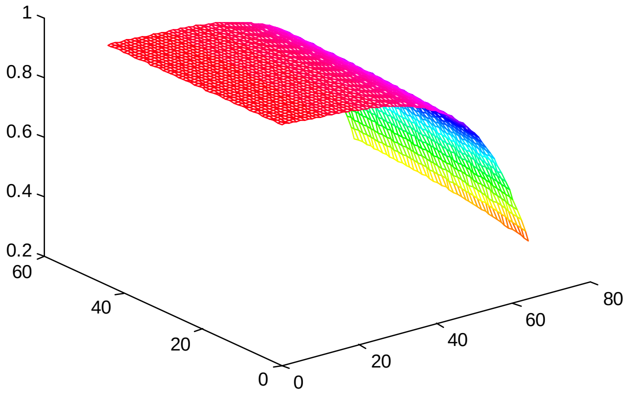


Figure A5: Unconditional Probabilities of Survival for the period $1995-2051$ (on the $x$-axis: age of the agents; on the $y$-axis: period $1995-2051$; and on the $z$-axis: values of the probabilities).

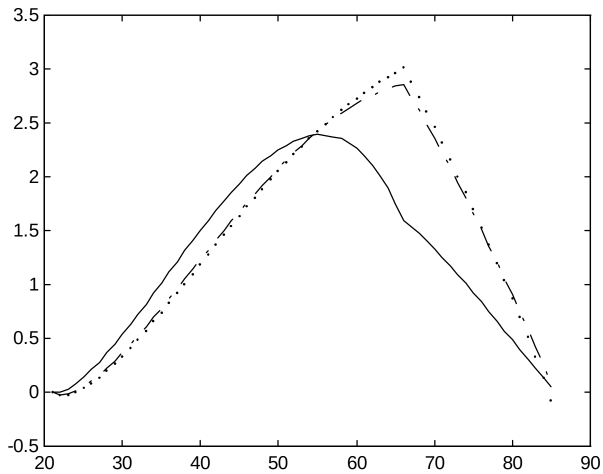


Figure A6: Age-asset holding profiles across steady states (the continuous line represents the profile for the ISS, the dash-dotted line the corresponding profile under Scenario I and the dotted line the profile according to Scenario II).

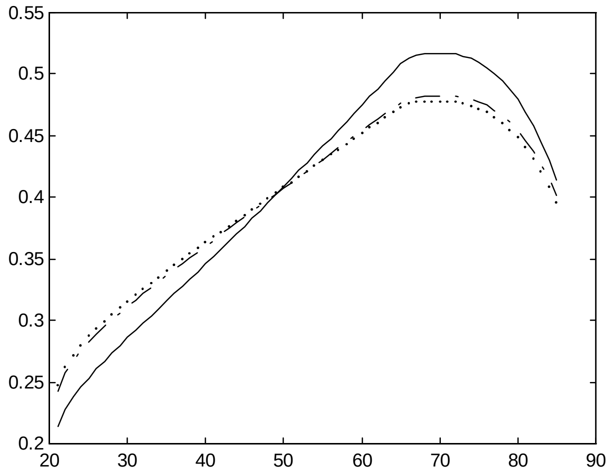


Figure A7: Age-consumption profiles across steady states (the continuous line represents the profile for the ISS, the dash-dotted line the corresponding profile under Scenario I and the dotted line the profile according to Scenario II).

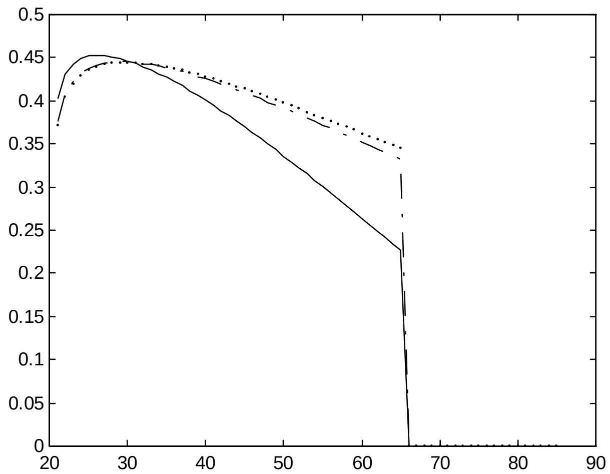


Figure A8: Age-labour profiles across steady states (the continuous line represents the profile for the ISS, the dash-dotted line the corresponding profile under Scenario I and the dotted line the profile according to Scenario II).