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Juan F. Jimeno, Juan A. Rojas
and Sergio Puente

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Juan F. Jimeno

BANCO DE ESPAÑA, CEPR, AND IZA

Juan A. Rojas

BANCO DE ESPAÑA

Sergio Puente

BANCO DE ESPAÑA

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**Abstract**

In this paper we survey the features of different approaches available in the literature used to study the effects of the aging of the population on Social Security expenditures. We comment on the weaknesses and strengths of each of them, and perform a quantitative analysis by comparing the results they imply in the particular case of the Spanish economy. Finally, we highlight some elements of the modelling strategies on which more evidence is needed for a correct evaluation of the problem at hand.

# 1 Introduction

During the forthcoming decades in most European countries the demographic scenario will dramatically change. The fall in fertility experienced during the last quarter of the XXth Century and the continuation of the rise in longevity will lead to a significant increase in the proportion of the older population. Thus, Social Security programmes, whose expenditures are very much determined by the size of the older population, will come increasingly under financial stress.

At least since the early 1980s there have been many studies trying to quantify the rise in Social Security expenditures as a result of population aging (see, for instance, World Bank, 1994, Roseveare et al. 1996). Nowadays, the task continues, as many political institutions are concerned by the budgetary implications of demographic changes. Over the years, the methodologies used to yield some quantitative forecasts of the likely evolution of Social Security expenditures have been improved and, nowadays there is a menu of alternative approaches to perform this task. In this paper, we survey the features of different approaches available in the literature used to study the effects of the aging of the population on the sustainability of the social security system. We group them into three categories that we label as: i) aggregate accounting, ii) general equilibrium models, and iii) individual life-cycle profiles. We highlight the weakness and strengths of each of them, and compare their predictions about the evolution of Social Security expenditures for the Spanish case. As it will be made clear, there are some crucial elements of these modelling strategies on which more evidence is needed for a correct evaluation of the problem at hand. Notwithstanding, all of the quantitative exercises we perform conclude that the points of GDP which, under the current pension schemes, would have to be devoted to expenditures in Social Security are significantly higher than current expenditures.

The survey is structured in four more Sections. Sections 2 to 4 present the main features of the three approaches we analyze (aggregate accounting, general equilibrium models, individual life-cycle profiles). Section 5 comments on the results from each approach when they are applied to study the Spanish situation. Finally, Section 6 contains some concluding remarks, mainly addressed to highlight some elements on which more microeconomic evidence is needed to improve the modelling of the impact of aging on Social Security expenditures.

# 2 Aggregate Accounting

A first approach at performing projections of the financial situation of Social Security consists of making a certain set of assumptions about the evolution of several key demographic and economic variables, and then using accounting identities to infer expenditures and revenues. Here we only focus on expenditures. Under this approach, the behavior of some agents and the functioning of markets is not explicitly modeled. This feature is precisely the main difference between these models and general equilibrium models, which are discussed in the next section.

By definition, pension expenditures are given by the following equation:

$$\text{Pension Expenditures} = \text{Number of pensions} \cdot \text{Average pension} \tag{1}$$

Typically the number of pensions are projected using population and employment forecasts over the future, where, for earnings-related pension schemes, employment years are converted into pension entitlements. Similarly, using some macroeconomic scenario for wage growth, average pensions into the future are computed by, first, computing the rate of growth of the benefits of new and current retirees and, secondly, taking out the benefits corresponding to exits due to deaths. There are many dimensions in which population and macroeconomic scenarios are enriched to improve the forecasting of Social Security expenditures.

In the next section we discuss the main ingredients needed to perform this type of exercises, that is, demographic and macroeconomic projections. But before discussing them, it is noteworthy that, under the same approach, there is an alternative, simpler way of making projections of Social Security expenditures. By scaling expenditures with respect to GDP[1]:

$$\frac{\text{Pension Expend.}}{\text{GDP}} = \frac{\text{Retired Population}}{\text{Employment}} \cdot \frac{\text{Average pension per retiree}}{\text{Average labor productivity}} = \tag{2}$$

$$= \frac{\text{Retired population}}{\text{Working age population}} \cdot \frac{\text{Working age population}}{\text{Employment}} \cdot \frac{\text{Average pension per retiree}}{\text{Average labor productivity}} \tag{3}$$

it follows that the ratio of pension expenditures to GDP is just the product of three factors: i) a demographic factor -the ratio of the retired population to working age population,[2], ii) a labor market factor -the inverse of the employment rate-, and iii) an institutional-economic factor -the ratio of average pension per retiree to average labor productivity, that very much depends on rules about computation of pension benefits and indexation of pensions, and other provisions determining how wage growth gets translated into the rate growth of the average pension. Using this breakdown, the uncertainty about the evolution of Social Security expenditures is reduced since i) the age structure of the population is easier to predict that just the size of each age cohort, ii) the employment rate has a lower range of variation that total employment, and iii) the ratio of average pension per retiree to average labor productivity is also easier to foresee as it depends on precise rules which can be specified under different scenarios.

Admittedly, these three factors may be interrelated, as alternative rules concerning the computation of benefits may imply different coverages rate of pensions, and may

[1] As done, for instance, in Boldrin et al. (1999).

[2] This ratio is often referred to as the "dependency ratio". If the coverage rate of the pension system -the number of pensions to the eligible population, remains contant, then this dependency ratio is just the quotient between the ratio of the number of pensions to employment and the coverage rate.

have different labor supply incentives so that the employment rate may also vary. To the extent that this effect can be considered of second-order importance with respect to the main determinants of each of the three ratios, equation (2) provides a, plausibly, rough approximation to the evolution of pension expenditures and to the impact of a particular pension reform on those expenditures.

## 2.1 Demographic Scenario

Any projection of Social Security expenditures relies on some conjectures about demographic developments. Typically, several pension projections are obtained by using alternative demographic scenarios. The key demographic variables determining the demographic scenarios are i) fertility rates, ii) life expectancy, and iii) migration flows.

Current fertility rates determine the size of the working age population two decades ahead. Obviously, a fall in fertility rates implies, in the forthcoming decades, a higher ratio of older population with respect to the working age population, and this rise of the dependency ratio lasts for more than just one generation, since in the future the size of women in childbearing age will be lower. As seen in Figure 1a, there was a noticeable fall in fertility rates in EU countries along the1970s that seems to be all but transitory, and, hence, will limit the size of the working age populations in the forthcoming decades. Nowadays, most population forecasts are based on the assumption of constant or only slightly increasing fertility rates in the near future. Figure 1b plots the assumption used by EUROSTAT for its more recent population forecasts (base 2004) in the baseline scenario.

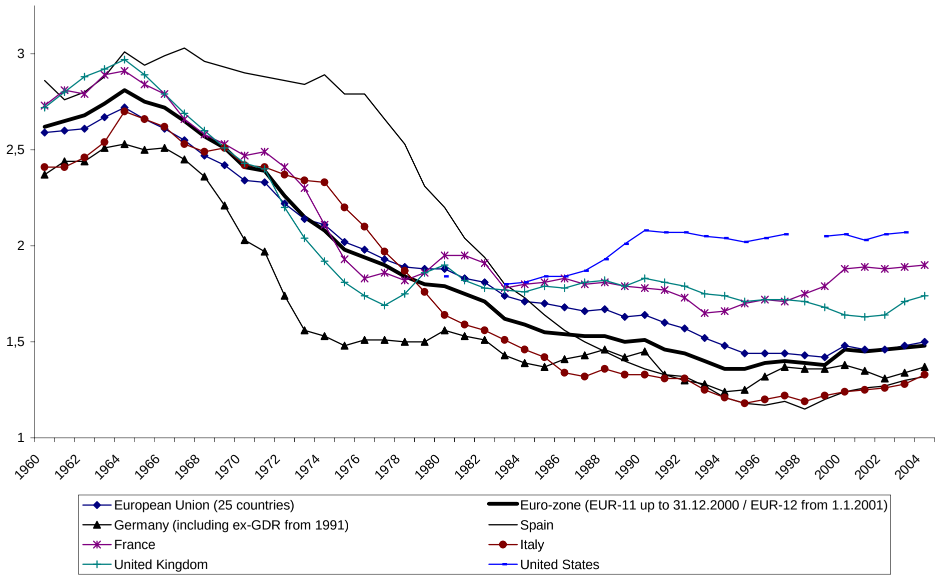


Figure 1a. Total fertility rates

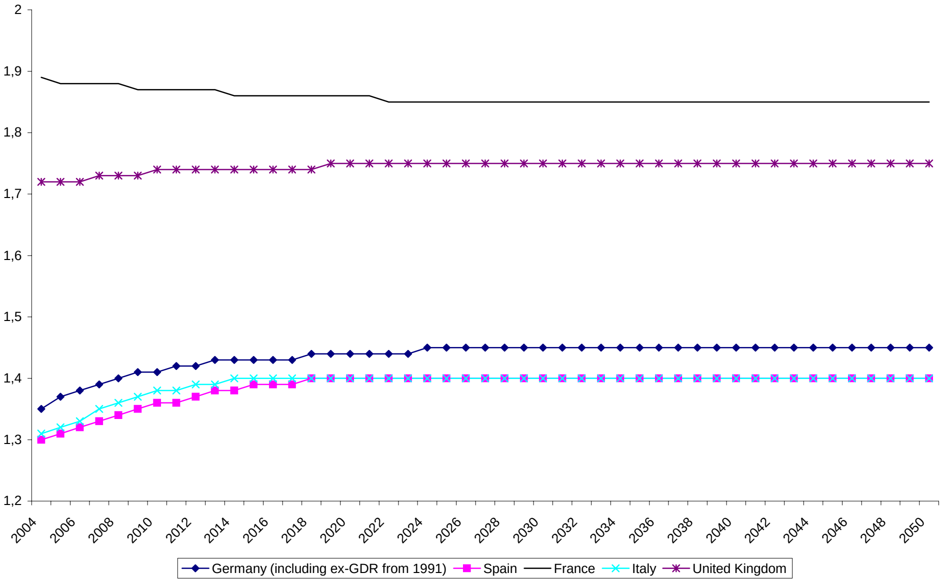


Figure 1b. Total fertility rates (assumptions, baseline scenario)
(Source: EUROSTAT)

A second important variable at determining the ratio of older population to the working age population is longevity. Figure 2 shows, by using life expectancy at 60 as an indicator, that it has increased without pause since the 1960s. In many countries, the rise has been of about 4 years for males and 5 years for females, that is, more than 1 year per decade. A roughly similar trend is expected to continue in many population forecasts for the forthcoming decades. For instance, the assumption used by EUROSTAT for its more recent population forecasts (base 2004) in the baseline scenario is that life expectancy at birth will increase by 6 years for males and by 5.3 years for women between 2004 and 2050. Notice that an increase of one year in both life expectancy and working life raises considerably the ratio of older population to the working age population, because such an increase represents, proportionally, a larger rise of average years in retirement.

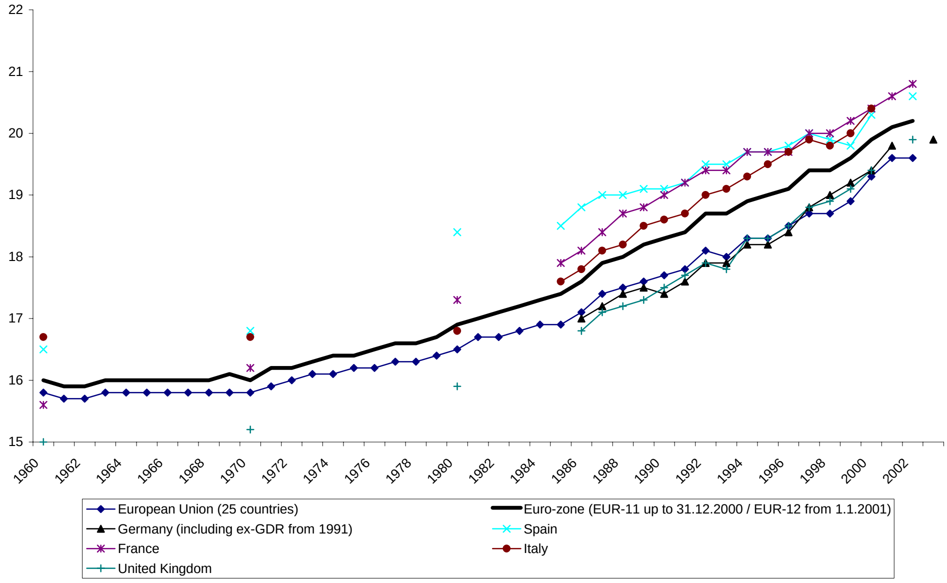


Figure 2a. Life expectancy at 60. Males.

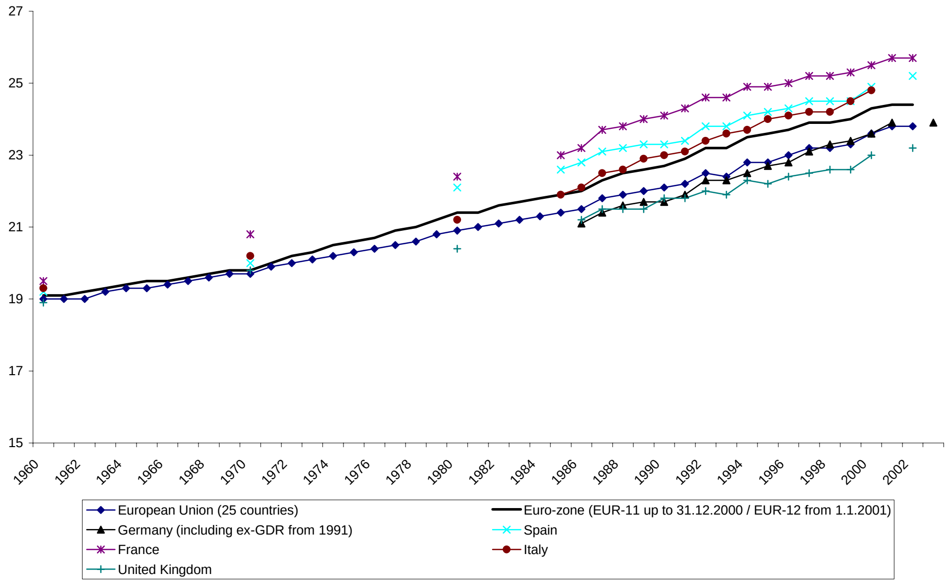


Figure 2b. Life expectancy at 60. Women.
(Source EUROSTAT)

Finally, there is migration, that could fill the gap in working age derived from the fall in births. Although there has been a surge of immigration into EU countries in the recent years, in particular into Southern Europe (see Figure 3a), there are two reasons to expect that immigration could not significantly change the age structure of the European population in the forthcoming decades. The first reason is that immigration flows are expected to either remain constant or fall (see Figure 3b). The second reason is that the effect of migration on the age structure of the population, even for large migration flows, depend on the age structure of migrants and its return patterns. Moreover, since immigrants will eventually age and retire, it could be the case that immigration could worsen the demographic pressures coming from ageing populations, more so in the case of a transitory higher level of immigration.

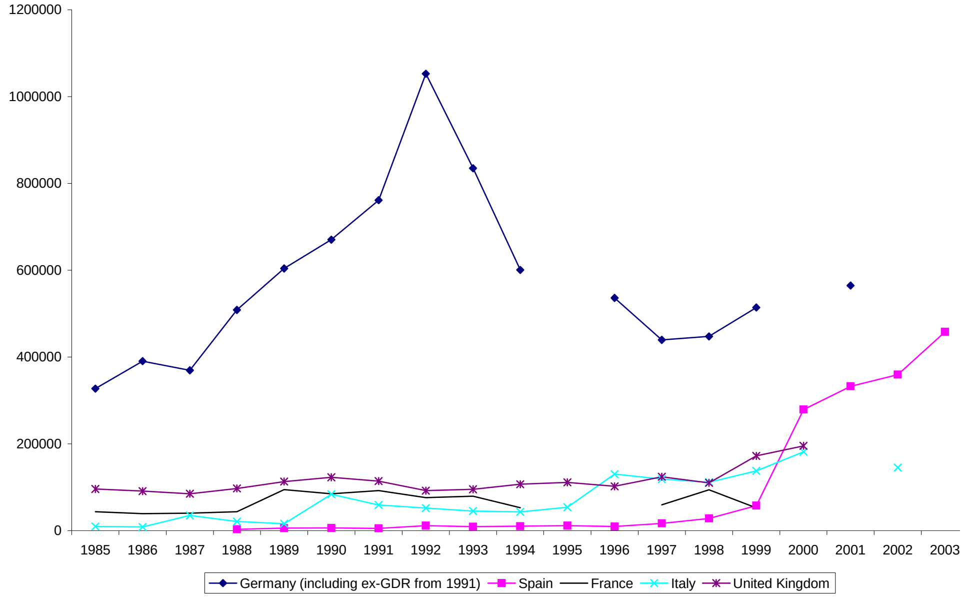


Figure 3a. Immigration flows (extra-EU, less than 65 years old)

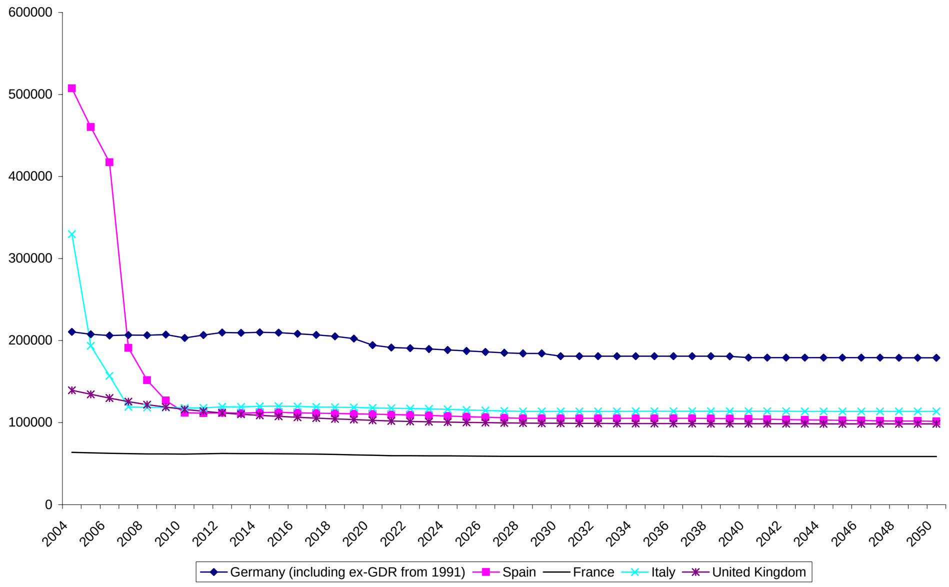


Figure 3b. Net migration (assumptions, baseline scenario)
(Source EUROSTAT)

In sum, the demographic scenario, under the most likely assumptions, is one of inevitable population ageing. Neither a small recovery of the fertility rate nor the arrival of a very large number of immigrants could significant change the trend towards the increasing weight of the older population, that could even becomes more acute if longevity rises more than expected. As a roughly approximation, under the current trends and the assumptions presented above, the ratio of the population older than 65 over the population 16-64 will, at least, doubles between 2004 and 2050 in most EU countries (see Figure 4).

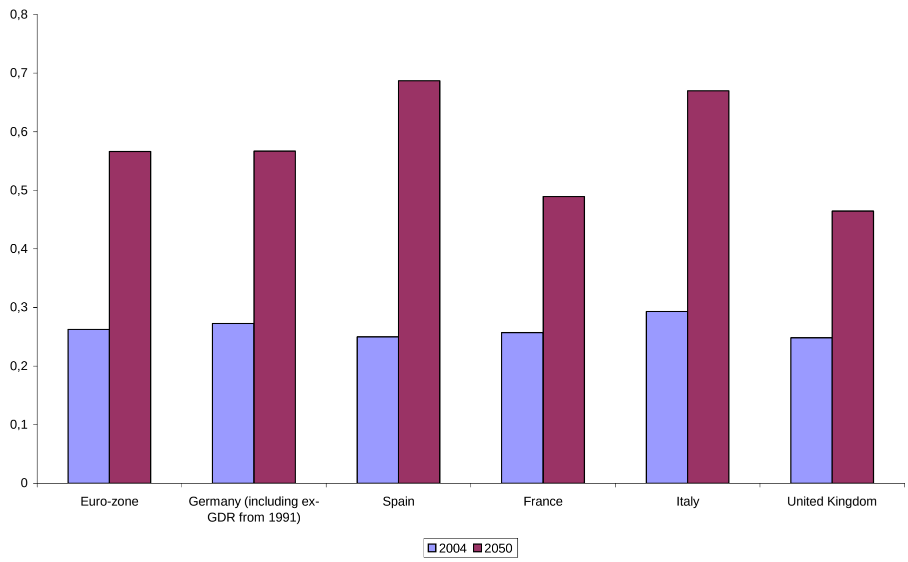


Figure 4. Population older than 65 over population 16-64

(Source: EUROSTAT)

## 2.2 Economic projections

### 2.2.1 The labor market

The key labor market variable, as far as modelling pension expenditures is concerned, is the evolution of the employment rate. First, in earning-related pension schemes, the employment rate of the current working generation determines the coverage and replacement rate of pensions when this generation retires. Secondly, the employment rate of the future working generation determines the size of GDP from which transfers to the retired population has to be drawn. As it is well-known, the performance of European countries in this regard is rather disappointing. First, unemployment rates remain high in some countries. Secondly, participation rates, particularly in later stages of the working lives (over 50 years) are unsustainably low. Figure 5 gives the recent evolution of employment rates in the major five EU countries showing that, apart for the catch-up of the Spanish employment rate, there is not any significant rise in the overall employment rate, and that the slightly increasing trend in female employment rates has just compensated for a fall in the male employment rate.

The future evolution of the employment rate will obviously depend on reforms undertaken to affect the functioning of European labour markets and, in particular, to augmenting the incentives to employment at older ages (see OECD 2005). In this regard, two points are worth noticing at this stage. First, under the current pace of reforms it is unlikely that employment rates in France, Germany, Italy or Spain will get closer to the Lisbon objective (70% in 2010). Secondly, as the share of older workers (45-65) increases, reforms will be especially needed to rise older workers employment.

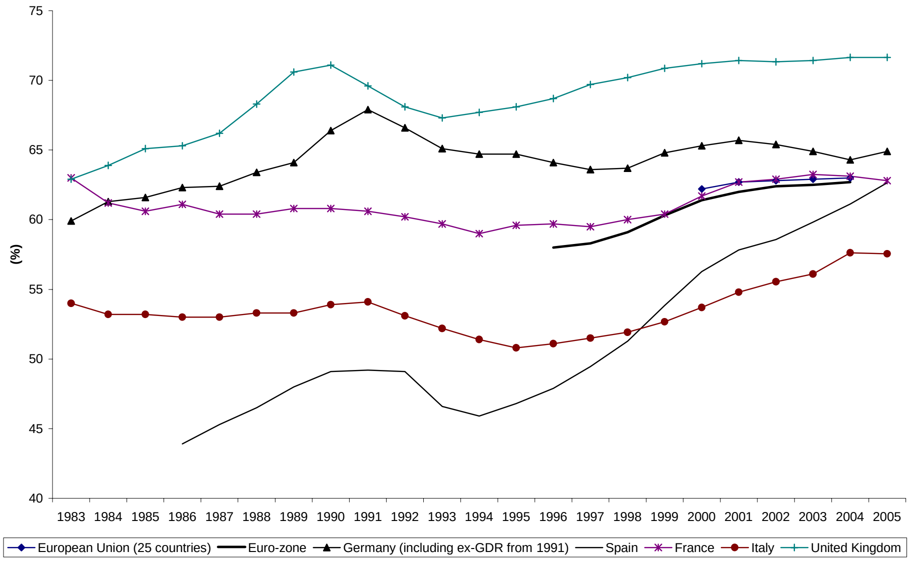


Figure 5a. Employment rates (population 15-64)

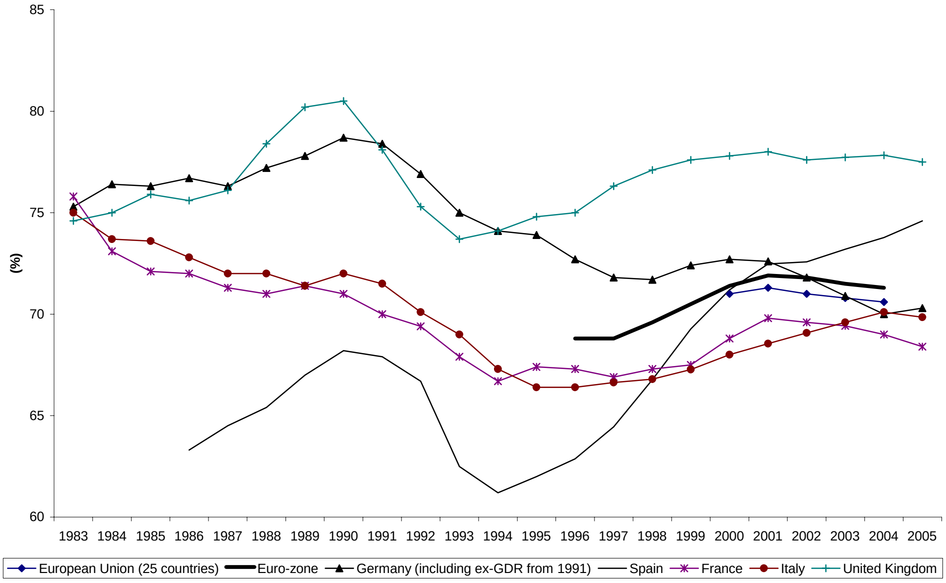


Figure 5b. Employment rates (males, population 15-64)

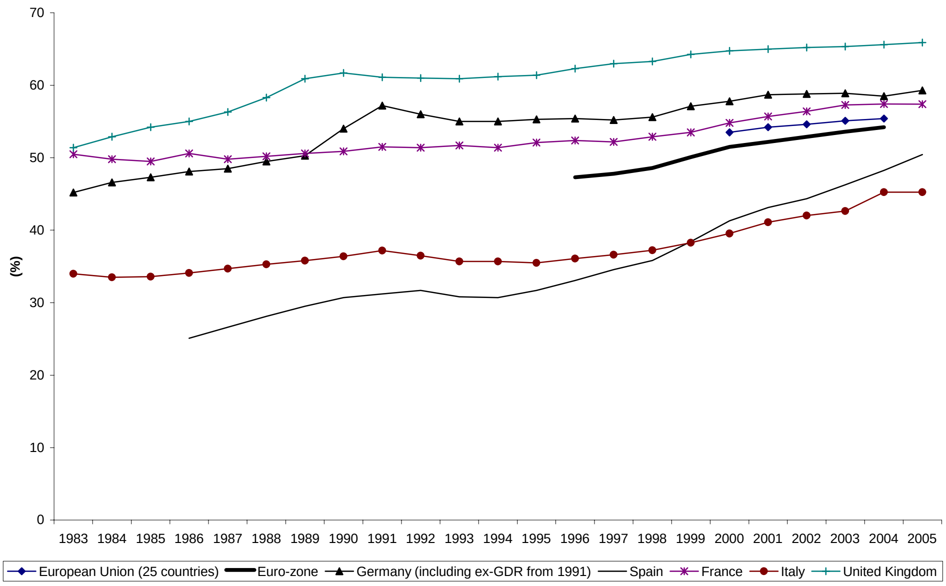


Figure 5c. Employment rates (women, population 15-64)
(Source: EUROSTAT)

### 2.2.2 Average pension benefits

The pension system in each country determines the amount that each individual will earn after his retirement. The rules determining coverage and amount of pension benefits very much change by countries. This, together with some differences in the current age structure of the population and the differences in employment rates, yield some heterogeneity in the levels of expenditures in social protection in old age (see Figures 6a and 6b).

Typically the projections of pension expenditures are done under the assumption of "unchanged rules". In many instances, this assumption delivers projections of pension expenditures well above the current levels. And it is easy to see why: Coming back to equation (2), if the demographic ratio increases by a factor of 2, the employment rate does not rise by much, and there is no change in the replacement rate of pensions since rules are unchanged, the proportion of GDP devoted to pension expenditures would have to increase also by a factor of 2.

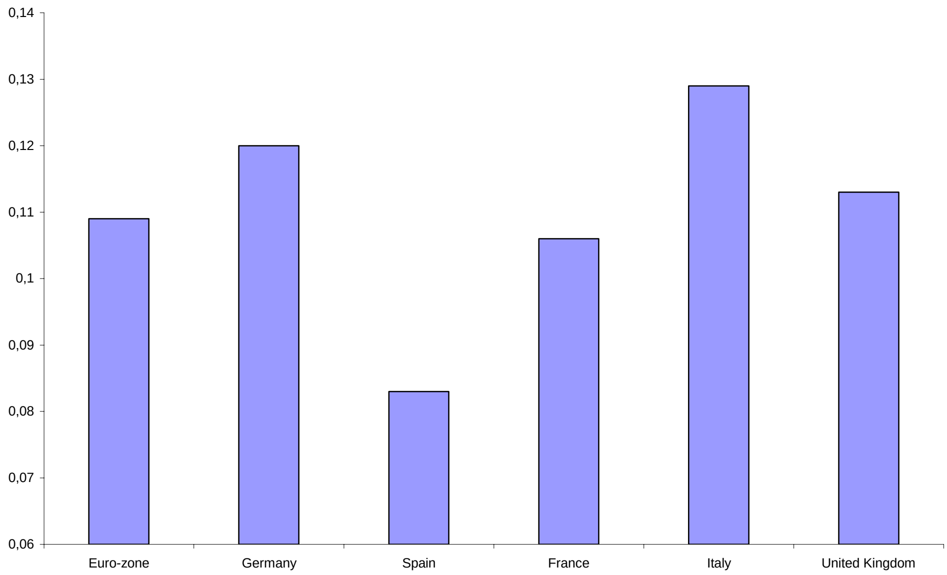


Figure 6a. Social protection benefits (Old Age, %GDP)

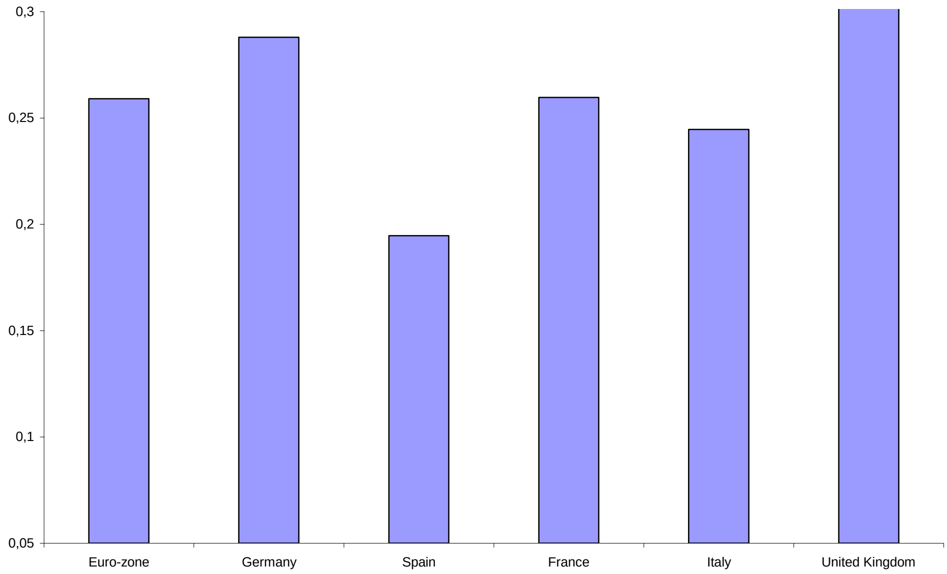


Figure 6b. Average benefit per retiree/GDP per worker*
(*By retiree we mean person aged 65 and older. The average benefit is computed as: $\frac{\text{Social protection expenditures in old age as a percentage of GDP*Employment rate}}{\text{Ratio of population older than 65 over population 15-64}}$)

### 2.2.3 The role of labor productivity growth

As employment rates, labor productivity affects the proportion of GDP devoted to pension expenditures in two ways. First, by determining current wages, in earnings-related schemes, it is closely related to future pension benefits. Secondly, under different scenarios for labor productivity growth, future average benefits as proportion of future average GDP per worker may change. There are several reasons. First, in many countries pension benefits are indexed to prices, rather than wages, so that high productivity growth implies a declining ratio of benefits to average productivity during the retirement period. Secondly, in many countries with earnings-related schemes, there is a cap on maximum pension, also typically indexed to prices, so that not all increases in wages are translated into future benefits.

Thus, non-linearities in the definition of pension entitlements (coverage and replacement rates) interact with both labor productivity growth and employment rates to change pension expenditures. Let's consider two examples. First, the number of years worked usually enters in the determination of pensions with a ceiling, i.e. years worked above some level will not improve pensions. Consequently, an improvement in the participation rate will either increase future pensions or not depending on the particular history of each agent. Hence, if the model does not take into account the heterogeneity in years worked, some bias can appear in the projection of average pensions. Second, pensions are often non linear in wages earned.[3] Consequently, wage variations will have different effects on pension levels depending on the wage level of each individual. Again, the absence of heterogeneity in wage levels in the analysis can produce biases.

Apart from heterogeneity considerations, what is important in projection exercises is to ensure that pension projections are consistent with the future evolution of wages and participation rates. To the extent that wages are undoubtedly related to labor productivity in the medium term, it can be expected that the evolution of pensions will be similar to the evolution of labor productivity, with a certain lag and apart from the effect of non-linearities commented above.

Finally, the evolution of employment, labor productivity and real GDP is linked by the fact that the latter is the product of the first two. Consequently, aggregate accounting models usually fix projections for two of them, and then use the mentioned accounting identity to infer the remaining variable. The way in which this is done can be problematic, because sensible projections for two variables need not imply a sensible evolution of the remaining variable. As an example, consider a demographic scenario characterized by a process of ageing, which imply that employment will fall. If, at the same time, the researcher assumes a real GDP growth in line with past rates, the consequence will be a very high and unbelievable productivity growth. Hence, it seems to be better to assume some trends for productivity and employment, and then infer real GDP.

[3] In Spain, there are minimum and maximum pension levels. Therefore, wage variations when the wage is outside certain interval will not imply any variations in pension levels.

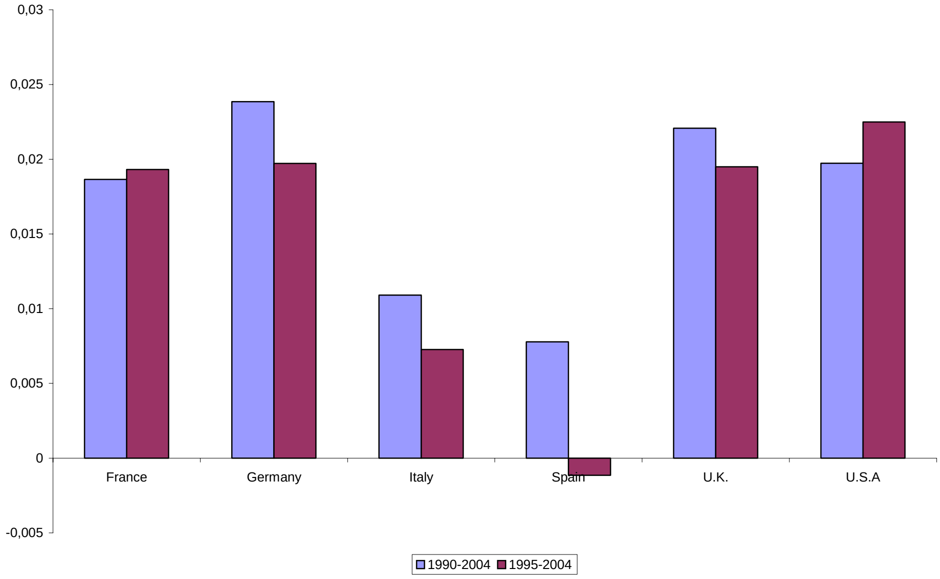


Figure 7. GDP per hour worked growth rate

(Source: Groningen Growth and Development Centre Database)

## 2.3 Sources of Heterogeneity

The sources of heterogeneity in an aggregate accounting model arise from agents with different ages, productivity, probability of employment, etc. The inclusion of each of these sources in the model will generate more accurate projections, but at the cost of increasing complexity and data needs.

Heterogeneity in age is usually taken into account. The procedure often involves an estimation of a life cycle wage profile.[4] The inclusion of several age groups in the model is very important when analyzing the ageing process, because individuals with different ages will have different productivity, and therefore a change in the age composition of the labor force implies a level effect on average productivity.

The inclusion of heterogeneity in productivity is very data demanding. For this reason, it is hardly included in aggregate accounting models. Its importance is, however, considerable. As mentioned above, there are non linearities in pension systems that cause the effects of certain changes to be different depending on the individual affected. Productivity can also be affected by other sources of heterogeneity, like education in different cohorts.

[4] The data source for this estimation that is often used fo Spain is the Encuesta de Estructura Salarial. It includes wage records for different variables, including age, for one year.

Agents can take different decisions concerning labor participation, or can have different employment histories. This source of heterogeneity is important again because of the existence of non linearities in the pension system.

Finally, the consideration of heterogeneity is also relevant when trying to model policy reforms, because the response of different agents to a policy change will be in general different. These responses involve, among other decisions, labor market participation, educational choices and voluntary retirement. However, the absence of an economic model in aggregate accounting models makes difficult the assessment of the effects of policy changes. As we will see in the next section, general equilibrium models can cope better with this problem.

# 3 General Equilibrium Models

## 3.1 Main Features and Methodology

The methodology underlying this approach consists of studying an artificial economy populated by rational agents (consumers, firms, etc.) that feature some preference objective function, the planning horizon and the nature of the uncertainty they face. Then, taking into account these objective functions, agents take decisions so as to maximize lifetime utility in the case of consumers, and profits, in the case of firms. The optimal decision rules obtained are aggregated and allow the researcher to derive the aggregate evolution of the macroeconomic variable of interest, which in turn, determine prices. An equilibrium is found when the prices used by individuals to optimize behavior are those that are consistent with the aggregate variables obtained from the aggregation of individual choices. Consequently, there is consistency between individual behavior and aggregate dynamics, a feature that is not always satisfied by other approaches. In the specific case of this paper, population aging will require some changes in government policies, which in turn will affect the behavior of the households composing the macroeconomy. For this reason, it is important to construct models that take into account how household behavior changes when the structure of taxes and transfers changes. This approach will yield results that are not subject to the Lucas' critique as compared to other methods that treat households' consumption, labor and savings decisions as constant and aggregate them according to the new demographic projections. Consequently the advantages of the large overlapping generations model are:

- They are microfounded and study equilibrium transitions induced by the aging of the population under several social security scenarios allowing for a perfect consistency between the evolution of micro and macro variables.

- They account for the endogeneity of factor prices and feedback effects.

- In most of them, since labor supply is endogenous, it is possible to capture labor market distortions associated with the reaction of the social security system to population aging. The source of endogeneity of labor supply may change depending on the study considered. For instance, in Sanchez-Martin (2001) the changes in the aggregate labor supply comes from variations in the optimal retirement age, while in Auerbach and Kotlikoff (1987) comes from changes in the age profile of labor effort, taking the retirement age as exogenously given.

## 3.2 A Benchmark General Equilibrium OLG Model

**Demographics.** The standard economy in this class of models is populated by agents that live a maximum of $I$ periods. Each type of agent is indexed by age $i$ and time $t$. Upon arrival at the age of $I_A$ an agent starts taking decisions. Each individual is endowed with 1 unit of time that can be allocated to work or leisure up to age $I_{R-1}$. After this age agents retire. Each agent faces an age dependent probability of surviving between age $i$ and age $i+1$ at $t$ denoted by $s_{i,t}$. Then the unconditional probability of reaching age $i$ for an individual that has age $v$ at $t$ is $\pi^i_{v,t} = \prod_{k=v+1}^{i} s_{k-1,t+k-v-1}$ with $\pi^v_{v,t} = 1$. Let $\mu_{i,t}$ be the share of age-i individuals over the total population at time $t$.

**Individual' behavior**. At each point in time agents are assumed to maximize lifetime utility. The problem of the typical agent that at $t$ has age $i = v$ $(v \geq I_A)$ is to choose consumption $c_{i,t}$ and leisure $l_{i,t} = 1 - h_{i,t}$ to solve

$$Max \sum_{i=v}^{I} \beta^{i-v} \pi^i_{v,t} U(c_{i,t+i-v}, h_{i,t+i-v})$$

subject to the following period-by-period constraint

$$a_{i+1,t+1} = (1 + r_t(1-\tau_k))a_{i,t} + y_{i,t} - c_{i,t}$$

with $a_{i+1,t+1} \geq 0$, $a_{1,t} = 0$, $a_{I+1,t} = 0$. The discount parameter is $\beta$, and is assumed to be the same for all agents. Borrowing is not possible and agents accumulate asset holdings to smooth consumption over time. $r_t$ is the interest rate net of depreciation, $a_{i+1,t+1}$ denotes next period asset holdings, $y_{i,t}$ is labor income net of taxes plus transfers and $\tau_k$ is a proportional capital income tax. Let $e_i$ be the efficiency index, $\tau_{ss,t}$ the social security proportional tax, $\tau_l$ a proportional labor income tax and $d_{i,t}$ the social security benefits. Finally $w_t$ denotes real wages and $B_t$ is the accidental bequest received at t. These considerations allow us to define the labor income net of taxes plus transfers as $y_{i,t} = w_t e_i h_{i,t}(1 - \tau_l - \tau_{ss,t}) + d_{i,t} + B_t$.

**Firms.** Production in period t is usually given by a standard constant returns to scale production function that converts capital $K_t$ and labor $N_t$ into output. The technology $A_t$ improves over time at a constant rate because of labor augmenting technological change, $A_{t+1} = (1+\lambda)A_t$, i.e

$$Y_t = F(K_t, A_t N_t)$$

**Public Sector.** The government levies a proportional social security tax on labor income $\tau_{ss,t}$ to finance a benefit $d_{i,t}$ per retiree. This system is assumed to be self-financed, i.e.

$$\sum_{i=I_A}^{I_R-1} \mu_{i,t} w_{i,t} h_{i,t} e_i \tau_{ss,t} = \sum_{i=I_R}^{I} \mu_{i,t} d_{i,t}$$

The government also levies a proportional tax on capital $\tau_k$ and labor $\tau_l$ income to finance per capita government consumption $G_t$ such that

$$\sum_{i=I_A}^{I} \mu_{i,t}(r_t a_{i,t} \tau_k + w_{i,t} h_{i,t} e_i \tau_l) = G_t.$$

**Equilibrium.** In this economy a *Competitive Equilibrium* is a list of sequences of quantities $c_{i,t}$, $h_{i,t}$, $a_{i,t}$, $\mu_{i,t}$, $d_{i,t}$, $L_t$, $N_t$, $K_t$, prices $w_{l,t}$, $w_{h,t}$, $r_t$, social security tax rates $\tau_{ss,t}$ and an income tax rates such that, at each point in time $t$:
1) firms maximize profits setting wages and the interest rate equal to marginal products,

$$w_t = F_N(K_t, A_t N_t)$$

$$r_t = F_K(K_t, A_t N_t) - \delta$$

2) agents maximize lifetime utility subject to the period budget constraints taking wages, the interest rate, taxes, transfers, survival probabilities and the age structure of the population as given,
3) the age structure of the population $\{\mu_{i,t}\}$ is generated by the following aggregate law of motion given initial conditions $\mu_{i,0}$, where $n_t$ is the population growth rate and $p_{i+1,t+1}$ is the age specific immigration rate and $\mu_{1,t+1}$ is the next period share of newly born agents

$$\mu_{i+1,t+1} = \frac{s_{i,t}\mu_{i,t}}{1+n_t} + p_{i+1,t+1}; \quad \mu_{1,t+1} = 1 - \sum_{i=2}^{I} \mu_{i,t+1}.$$

4) Market clearing conditions for capital and labor,

$$K_t = \sum_{i=I_A}^{I} \mu_{i,t} a_{i,t} \; N_t = \sum_{i=I_A}^{I_R-1} \mu_{i,t} e_{i,t} h_{i,t}$$

5) Finally, the budget constraint of the government is satisfied period by period. Hence with these conditions the goods market clears every period,

$$F(K_t, N_t) + (1-\delta)K_t = K_{t+1} + G_t + \sum_i \mu_{i,t} c_{i,t}.$$

## 3.3 Exogenous Parameters in these models: Calibration

The first step is to specify the primitives of the model, such as the form of the utility function and the production function. Second, in order to use this approach to answer quantitatively the question at hand, the model parameters (for instance the degree of risk aversion and the intertemporal subjective discount factor) have to be chosen. Usually, this step is performed by setting most of them in such a way that after solving the model for the initial year of the simulation, the artificial model economy matches some key macroeconomic aggregates of the real economy studied. Those parameters that cannot be chosen in such a way, are usually set to some range based on some empirical work. In what follows we show how a model of this type can be calibrated.

Agents reach adulthood at 20 and may live up to age 95, after which death is certain. Each model period corresponds to 5 years. We may take the age structure of the population of 1995 as the initial condition. The standard models use a utility function of the constant relative risk-aversion class

$$u(c,l) = \frac{(c^{\theta} l^{1-\theta})^{1-\sigma}}{1-\sigma} \tag{4}$$

where the inverse of the elasticity of substitution $\sigma$ and the share of consumption $\theta$ is usually set such that the average time spent working is around 1/3 and the intertemporal elasticity of substitution is consistent with the empirical estimates as those reviewed in Auberbach and Kotlikoff (1987). Hence $\sigma = 2$ and $\theta = 0.33$. The discount rate parameter is set equal to $\beta = 0.987$ so as to reproduce a private capital-output ratio of 2.5 in the Spanish economy as reported by Puch and Licandro (1997). As is standard in large overlapping generations models, in order to allow for the fact that earnings grow with experience agents are endowed with an exogenous profile of age specific efficiency units $e_i$. This may be done using the cross-sectional distribution of gross hourly wages in 1993 available in the European Household Panel (1994). The endowment of efficiency units is determined by dividing each cohort's average wage by the average of the sample and then by smoothing the wage profile with a polynomial of degree two.

The production function is Cobb-Douglas where the capital share parameter is $\alpha = 0.375$ following the estimates of Domenech and Taguas (1995) for the Spanish economy. The productivity growth has been set to $\lambda = 1.5\%$ in annual terms which is the average growth of per-capita consumption over the period 1960-1995. Hence,

$$Y_t = F(K_t, A_t N_t) = K_t^{\alpha}(A_t N_t)^{1-\alpha} \tag{5}$$

Finally, firms rent labor and capital at given wages and net interest rate to maximize

$$F(K_t, A_t N_t) - (r_t + \delta)K_t - w_t N_t$$

where $\delta$ is the depreciation rate for capital and is set to match the average ratio of gross investment over output I/Y=24%. This yields a value of $\delta = 9\%$ in annual terms. Social security benefits are computed as follows. Upon retirement an individual's pension is computed applying a replacement rate over the average of earnings of the last 8 years before retirement. This replacement rate is 100% if the individual has contributed for at least 35 years. The pension system in Spain also includes a maximum and a minimum pension level but given that individuals of the same generation are assumed to be homogeneous in this basic model we abstract from this feature. The capital and labor income tax rates are $\tau_k = 0.186$ and $\tau_l = 0.17$ respectively as reported by Bosca et al. (1999). These values generate a government to output ratio of $G/Y = 0.13$ which is consistent with the average of this number from 1970 to 1994 in Spain.

Having specified the primitives and the parameter values of the model, the only additional input required in order to obtain the future evolution of the aggregate variables that includes the percentage of GDP spent in pensions is the expected evolution of the demographic structure of the population. In particular, the procedure to propagate the economy after the initial year uses the law of motion of the population shown in the definition of equilibrium and some database (like INE or Eurostat Demographic Statistics 1996) to obtain the expected evolution of the population growth rate, the mortality rates and the migration rates from 1995 to 2050. In order to compute the final steady state, after 2050 we may fix the net migration rates and the survival probabilities of that year and let the age structure run until it reaches a stationary structure characterized by a population growth rate equal to zero. This means that in contrast to other approaches this modelling strategy does not require any assumption about future behavior of other variables like labor supply and wages, since those are endogenously determined into the model, after the proper aggregation of individual choices and macroeconomic equilibrium conditions.

In summary,

- Dynamic general equilibrium models only require specifying the primitives and some base parameters and can endogenously display the dynamics of macroeconomic variables, accounting for the behavioral response of individuals. In contrast, the Accounting Approach requires many assumptions about future variables and more importantly, behavioral responses to fiscal policies are not considered. This question is important in order to ensure aggregate consistency across variables. To put an example, in the accounting approach, the evolution of GDP growth rate and the pension level per retiree are exogenously and independently specified, meanwhile in the general equilibrium methodology, both variables are linked and endogenously determined as a function of the demographic projection specified.

## 3.4 Sources of Heterogeneity

One of the features of the standard overlapping generations model outlined above is that there is no intragenerational heterogeneity. This may be an important shortcoming for at least for two reasons. First, if all the members of the same generation are equal, there is no way of analyzing several aspects of pay-as-you-go (PAYG) systems, such as the incentives and distributive effects created by the existence of minimum and maximum pension levels. In addition, a PAYG system may be welfare improving because it partially substitutes for missing markets that help individuals to insure against income risk (Imrohoroglu et al (1995)). Consequently, if a researcher is interested in analyzing these issues, individuals of the same generation must either face some income risk so as to generate ex-post intra-generational heterogeneity or be ex-ante herogeneous in terms of, for instance, labor market productivity.

An example of the first approach is De Nardi, Imrohoroglu, and Sargent (1999) and an example of the second is Kotlikoff, Smetters and Walliser (2000). For the specific case of the Spanish economy there are two studies that model deterministic heterogeneity explicitly. Sanchez-Martin (2001) considers the case of four educational categories in each cohort, allowing for the study of early retirement patterns of those individuals with low income levels and Rojas (2005) considers the case of 21 income levels per generation. Although in the latest the retirement decision is exogenous, in both cases the high level of heterogeneity and the fact that the pattern of pension benefits is correlated with labor earnings before retirement allows them to take explicit account of the existence of maximum and minimum pension limits when analyzing the impact of aging on the finances of the social security.

Since solving this kind of models is computationally very intensive, there is still room for improving the way heterogeneity is modeled. For instance, this methodology usually abstracts from unemployment risk, and the way in which different social security regimes may affect the incentives to accept or reject job offers. A shortcut route to capture a richer labor market's status is taken by Borsch-Supan, Heiss, Ludwig and Winter (2002) who use a general equilibrium overlapping generations model in which members of the same generation are sorted into the categories of employment, unemployment, non participating and retirement so as to be able to track the possible evolution of aggregate labor supply, with the aim of studying the effects of aging on the rate of return on capital. Although in their model generations take consumption and saving decisions as in the standard model outlined above, the labor market status is deterministic and exogenously given to households, and consequently there is no feedback from changes in aggregate conditions (like pension rules) into individual's incentives to retire early or to participate or not in the labor market. Moreover, since the decision maker is a generation, although members of the same generation are composed of individuals with different labor market status, they all take the same consumption and saving decisions, i.e. it is like having full risk sharing among all the members of a cohort.

# 4 Individual life-cycle profiles

## 4.1 Main Features and Methodology

Typically in most pension systems benefits are computed in two steps: first, conditions for eligibility, and, secondly, determination of the amount of benefits. As an example, under earnings-related system eligibility is achieved only with a minimum number of years of contribution. Benefits are awarded depending on some average wage with the first years of contribution giving less "pension points" than the years of contributions close to the retirement age. These formulae are not always easy to replicate in a simple condition to be introduced in general equilibrium models. And being non-linear, they imply that, under heterogeneity, the benefits for the average worker is not the same as the average benefit across workers. Although, admittedly, some heterogeneity can be introduced in general equilibrium models, as discussed above, this can be done only to a limited extent, as the aggregation of many heterogenous agents soon face computation constraints.

Thus, when facing distributional issues related to pension reforms, some studies have dropped the general equilibrium discipline and turn to simulations of many different individual profiles to compute the distribution of pension benefits under different rules. For instance, Deaton, Gourinchas and Paxton (1999) analyse the implications of pension reforms for consumption inequality along the life cycle and find that defined-contribution systems yield more inequality before and after retirement. Coronado, Fullerton and Glass (2000) show that the degree of progressivity in the US pension system depends upon assumptions on discount rates and the expected duration of the life cycle across cohorts of different income levels. Feldstein and Liebman (2000) compute pension benefits that cohorts born during the period 1925-1929 would have receive under a defined-contribution, fully-funded system. Finally, Bosworth and Burtless (2002) perform a simulation analysis of the risk that individuals would face after a transition to a defined-contribution, fully-funded system.

This approach, namely, simulating many individual life-cycle profiles and computing outcomes under different alternative pension rules, is, in spirit, close to the Generational Accounting framework proposed by Auerbach and Kotlikoff (200x). Under this framework, individual accounts of net transfers with the government are computed to make some judgements of the sustainability of government finances. Similarly, for individual following different employment status along the life cycle, entitlements to pension benefits can be computed under different rules. In the next subsection we provide more details about the implementation. What it is worth noticing at this stage is that the richness of considering many different individual life-cycle profiles come at some costs: i) in contrast with general equilibrium models, the evolution of factor prices (wages and interest rates) is assumed to be determined by exogenous factors, other than labour demand and labour supply, and the saving decisions of the individual, respectively, ii) the changes in behavior introduced by changes in the pension system rules are also conjectured rather than estimated or calibrated from some microeconomic evidence.[5]

## 4.2 Implementation: An example

As commented above, the simulation of life-cycle profiles is usually performed to compare the distributional consequences of alternative pension schemes. As a by-product, with the appropriate assumptions about demographic evolutions (size and composition of the population), it can also yield accurate forecasts of the financial flows of alternative pension systems. We now describe how this approach is implemented and how could be used for the quantitative analysis of the impact of aging on Social Security expenditures.

The main ingredients are group-specific variables determining employment status and life duration. For each age cohort, some composition by education, gender, and any other co-variate needs to be postulated. Within each cohort, individuals enter the labour market with a different age depending on educational attainment. Given group-specific flow rates between inactivity, unemployment and employment, the employment status of each individual at each period is drawn from any density mimicking the observed flow rates. Group-specific survival rates determined the life duration of each individual. Before retirement , individuals contribute to Social Security. Contributions, given some pension rules, could vary depending on the individuals' employment status and wages, which are drawn from the empirical distribution of wages by age, educational levels, and other available co-variates. After retirement, individuals receive pension benefits determined by their years of contribution and earnings, according to existing pension rules. The retirement age could be

[5]Even under general equilibrium, in a small open economy the interest rate is determined exogenously. As for microeconomic evidence on the labour supply incentives of alternative pension rules, we will come back to this issue in the final section.

either exogenously determined, using also the empirical distribution of the flows into retirement by the observed co-variate, or, alternatively, by the flows into inactivity and unemployment of individuals close to retirement age. Aggregating across individuals, average pension benefits and its average duration for each cohort can be easily computed. Total pension expenditures at a given period is obtained by aggregation across all age cohorts.

This approach has one main advantage and some loopholes. The former is that it allows to characterize a richer distribution of contributions and benefits regarding Social Security than the one which can be constructed under general equilibrium models. The latter arise from the possible effects of pension reforms on labour supply and labour demand decisions that are behind the flows among employment states and the wage distribution. In this regard, some informed conjectures could be added to the computation of the impact of aging on Social Security finances, but this is an issue to which we will return in the final Section of the paper.

# 5 Illustration: Results from the different approaches applied to the Spanish case

In this section we will try to present some examples of the different approaches reviewed previously, applied to the Spanish case. We compare them in terms of their implications for variables like the ratio of pension expenses over GDP, or the ratio of average pension over average labor productivity. We do so by using the current situation of the Spanish pension system. We draw on some projections under the three different approaches available in the literature and perform some simple, new projections under the first approach. We will also consider the predictions of each approach with regards to the impact of a specific (parametric) pension reform on pension expenditures. Thus, we comment on the consequences for expenditures of a change in the computation formula of benefits of an earnings-related scheme (as it is the Spanish pension scheme) coming from the rise in the number of years of contribution considered for the determination of pension benefits.

For this exercise, our demographic scenario is based on the new set of demographic projections made available by the Spanish Statistical Office (*Instituto Nacional de Estadística, INE, www.ine.es*). Among the different scenarios contemplated by INE, we choose the scenario with the lowest rise in the ratio of older population to the working age population. In Figures 8a to 8c we plot the assumptions for the demographic variables underlying this scenario. These are more optimistic than those of EUROSTAT regarding the recovery of fertility and the arrival of new immigrants. Figure 8d plot the resulting ratio of the population 65 and older over the working age population (16-64) resulting from these assumptions. This ratio is projected to rise from 25.1% in 2004 to 56.0% in 2050 and to 53.3% in 2059.

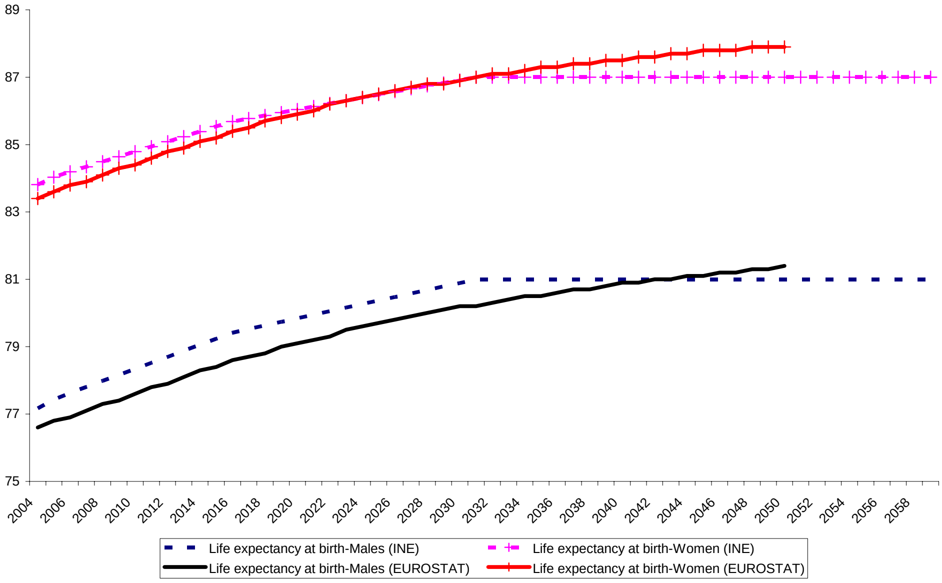


Figure 8a. Demographic assumptions. Life expectancy at birth

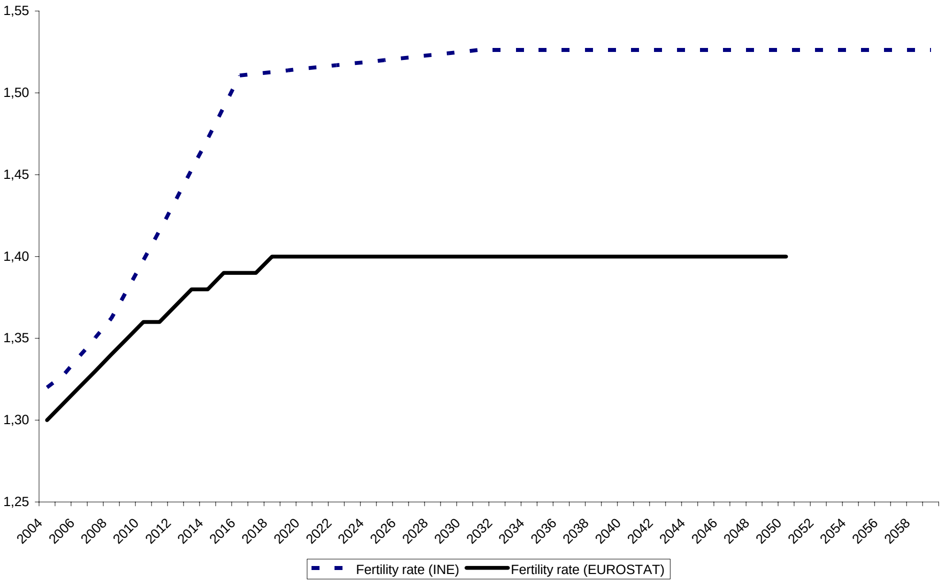


Figure 8b. Demographic assumptions. Total fertility rate

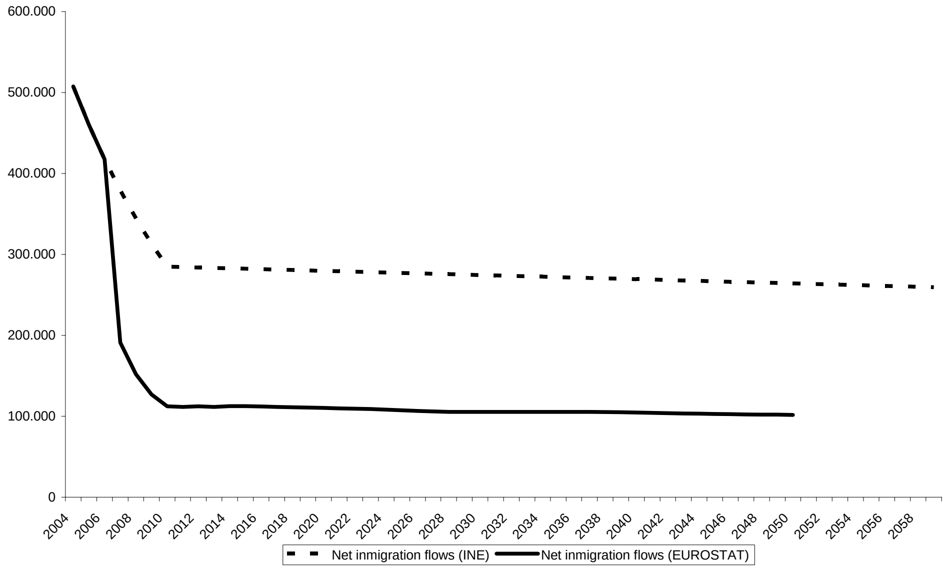


Figure 8c. Demographic assumptions. Net immigration flows

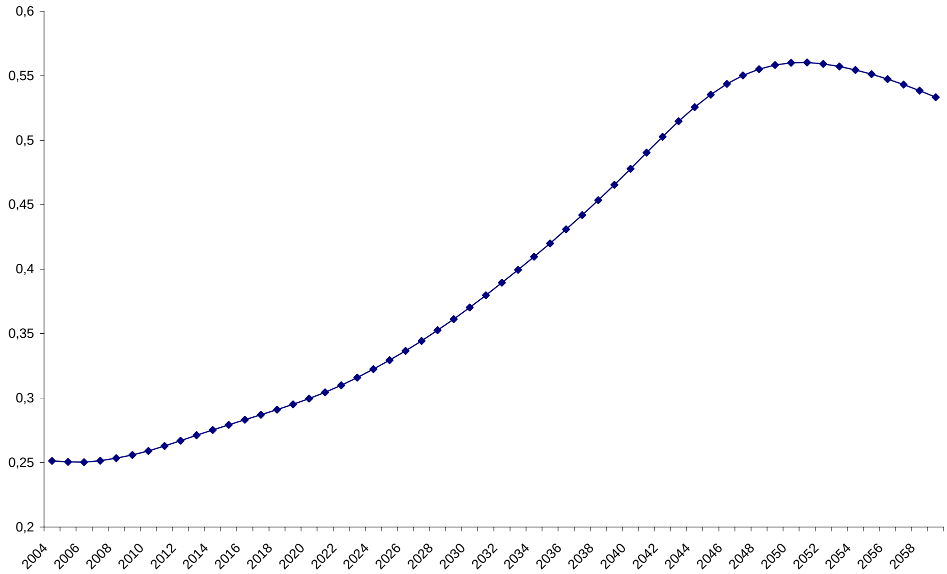


Figure 8d. Population 65 and older over population 15-64 (INE, assumptions)

As for the employment rate, in our baseline scenario we use the current employment rates by age groups (in 5 year cohorts and by educational attainments -primary, secondary, and tertiary). We assume that these employment rates remain at the current levels (see Figure 9a) and that the composition of the population by age changes according to the INE projections. We assume that the educational composition of the cohorts older than 30 years of age in 2050 converges to the current composition of the cohort 30-35 years of age. As a result, the employment rate is 64.5% in the year 2050, just about 1.5 p.p higher than the current one. In this projection, there are two opposite effects. As the population ages, the overall employment rate falls, since older workers have lower employment rates than prime-age workers. On the other hand, education levels of the older cohorts are projected to increase and, thus, the overall employment rate rises.

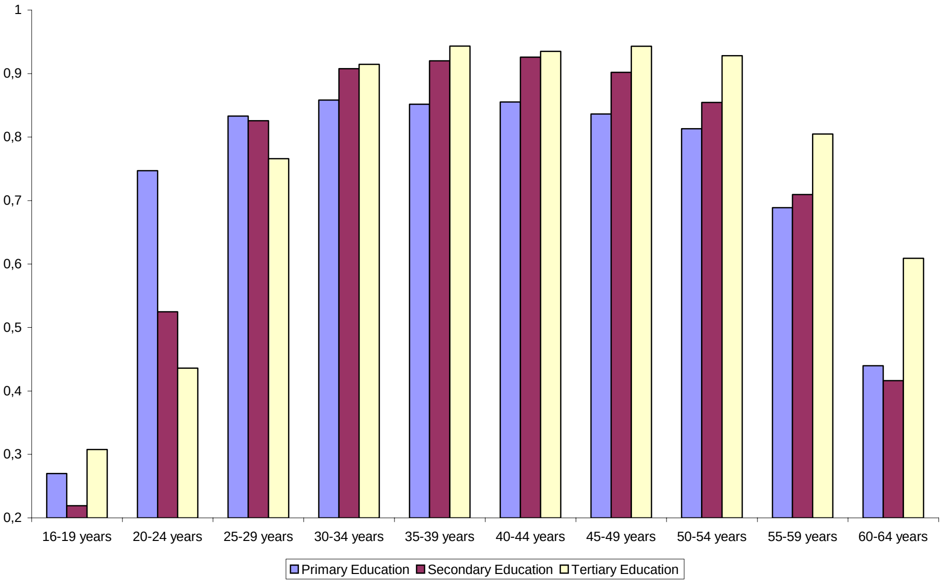


Figure 10a. Employment rates by age and education. Males

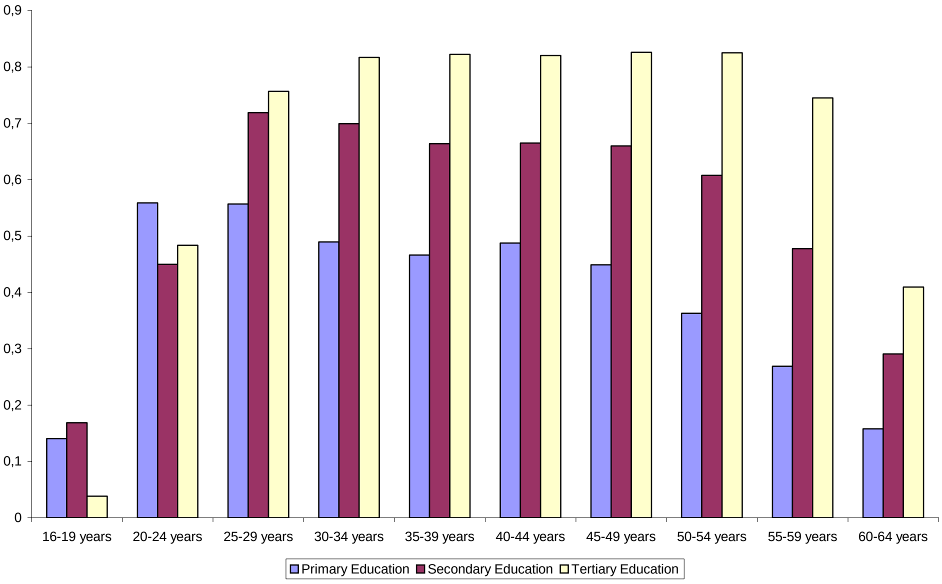


Figure 10b. Employment rate by age and education. Women
(Source: Labour Force Survey)

Table 1 reports the projections of pension expenditures under different methodologies and scenarios. In the baseline scenario described above, pension expenditures would rise by 10 p.p. of GDP, from 9% to 19.6% of GDP, despite the increase in the employment rate, brought up by the educational upbuilding of older cohorts, and the invariance in the "generosity" of pensions, measured as the ratio of average benefit per retiree to GDP per worker. Alternatively, under a more favorable scenario, assuming that the employment rate reaches 70% and that higher productivity growth can reduce the ratio of average benefit per retiree to GDP per worker by 10%, the rise in pension expenditures between 2005 and 2050 would be 7 p.p. of GDP, from 9% to 16% of GDP.[6]

As for the general equilibrium approach, there are several studies that have addressed the effects of aging on the social security system in Spain using computable overlapping generations models. The first was Montero (2000). Using a model calibrated to Spain, she analyzed the aggregate impact of two demographic scenarios. One characterized by the survival probabilities of 1995 and the average population growth rate between 1961 and 1995, and another characterized by zero population growth rate. Although she does not report the change in the percentage of GDP spent on pensions, she finds that keeping constant the level of pension per-capita would imply an increase of 10% points in the social security tax rate. Unfortunately, in that paper there is no transitional dynamics and consequently it cannot be used to provide medium-term forecasts of the pension-GDP ratio.

However two recent papers have used official demographic projections for the Spanish economy to report different measures of the sustainability of the pension system from 1995 to 2050. Rojas (2005) studies the impact of demographic projections in the Spanish economy by comparing the equilibrium allocations in two model economies (G.E. 1 and G.E. 2, respectively) where households choose consumption, saving and labor supply optimally along the life-cycle, but differ from each other in the degree of substitution of workers with different experience levels. Results indicate that there are quantitatively relevant differences between both economies. For instance it is found that if the rule used to compute pension benefits is left untouched, in the standard model (G.E. 1) the percentage of GDP spent on pensions will increase from 7.7% in 2000 to 19.4% in 2050. In contrast, in the model economy with cohort size effects (G.E. 2) this percentage will increase from 7.6% in 2000 to 15.9% in 2050. The mechanism that accounts for such difference is the lower pension benefits of individuals belonging to the baby-boom generation in the model economy with cohort size effects. This is so due to the fall in the experience premium and the reduction of labor effort before retirement displayed by the members of the baby-boom generation as part of the intertemporal reallocation of hours worked in response to the fall in relative wages.

[6] For other projections of pension expenditures using the aggregate accounting approach, see Jimeno (2000), Blanco et al. (2000) and Herce and Alonso (2000).

**Table 1: Pension Expenditures: Projections under Different Methodologies and Scenarios**

| | Aggregate Accounting (Baseline) | Aggregate Accounting (+Employment, +Productivity) | General Equilibrium (G.E.1) | (G.E.2) |
|---|---|---|---|---|
| | 2005 | 2005 | 2005 | |
| Dependency Ratio (+65/(16-64))(%) | 25.1 | 25.1 | 25.5 | 25.5 |
| Average benefit per retiree/GDP per worker (%) | 22.6 | 22.6 | | |
| Employment rate | 63 | 63 | | |
| Pension expenditures/GDP | 9.0* | 9.0* | 7.9 | 7.7 |
| | 2050 | 2050 | 2050 | |
| Dependency Ratio (+65/(16-64))(%) | 56.0 | 56.0 | 56.5 | 56.5 |
| Labor Productivity growth (2005-2025) | 2 | 2 | 1.6 | 2.0 |
| Labor Productivity growth (2025-2050) (%) | 2 | 2 | 1.5 | 1.5 |
| Average pension/average productivity (%) | 22.6 | 20.0 | | |
| Employment rate | 64.5 | 70.0 | | |
| Pension Expenditure/GDP (%) | 19.6 | 16.0 | 19.4 | 15.9 |

Note: *Benefits under the Social Security General Regime (provisional estimate)

An unpleaseant feature of this model is that the retirement age is exogenous. In contrast, other recent study is Sanchez-Martin (2001), who considers a large overlapping generations model where the changes in the labor supply stems from changes in the retirement age endogenously chosen by individuals. Under a plausible calibration of several aspects of the pension rules in Spain, he successfully reproduces the pattern of early retirement of low income households. He also studies the effect of population aging under alternative social security's scenarios and finds that if the pension rules are left untouched at the level of 1995, the aging of the population will almost double the percentage of GDP spent on pensions from 2000 to 2050. In addition, he finds that the retirement pattern across income groups (and the average retirement age) is not affected by the macroeconomic changes induced by aging. A result that might be explained by the low level of intra-generational heterogeneity (4 income groups) and the log utility function assumed. An interesting route to follow would be to study whether this result survives the introduction of more complex heterogeneity and more general utility functions. In this sense, a recent paper by Diaz-Saavedra (2005) finds that in a model calibrated to the spanish economy the average retirement age is likely to increase, due to the change in the educational composition of the population over the coming decades.

Finally, it is worth noticing that the results under the different approaches can differ for a number of reasons that are not directly related to the nature of each methodology. First, the base year and the sources of input data do not necessarily coincide. Secondly, they use in general different definitions of pension expenditures, including different concepts in the definition. Finally, the structure of the model and the calibration procedure in general equilibrium models could cause certain variables to be different than observed ones. All of the above must be kept in mind when comparing the figures in Table 1. However, despite all these cautions, the common message is that the impact of ageing on Social Security expenditures could be quite significant, even under the most favorable scenarios and with or without accounting for other changes in macroeconomic variables brought up by ageing.

## 5.1 Quantifying the impact of a pensions reform

The methodologies outlined above are used not only to project pension expenditures into the future, but also to simulate the effect of alternative pension reforms. While there are many pension reforms which could be considered, they are typically classified into two groups: i) parametric reforms, involving some changes in the rules for entitlements and the computation of benefits, and ii) non-parametric reforms, changing the nature of existing pension schemes, such as, for instance, moving from "Pay-As-You-Go-Sytems" (PAYG) to fully capitalized systems.[7]. As far as the goal of this paper is concerned, i.e., modelling the impact of ageing on pension expenditures, we focus on the first class of reforms. We illustrate the results of the different methodologies at analyzing parametric reforms, by considering a change in the benefit computation formula in the Spanish pension scheme.

Currently, in Spain, old-age pension benefits are computed as a proportion (determined by the years of contribution and age at retirement) of the average contribution base during the last 15 years of the working life.[8] Both the contribution base and the resulting pension are capped by minimum and maximum bounds. As a measure to control expenditures and also to improve the "equity" of the system, it is often postulated to increase to 30 years, or even to the whole working life, the period used to compute the average contribution base entered into the benefit formula. In what follows, we report the results of different studies which have simulated the effect of this type of reform on the projections of pension expenditures.

In aggregate accounting models, the only effect of this type of parametric reforms that are considered in the analysis is its impact on the evolution of benefits. Indirect effects on the employment rate or on productivity growth coming from labour supply or labour demand effects are not computed. By contrast, in general equilibrium models, reforms are analyzed starting from an initial steady state characterized by the existing pension rules, and the associated behavior of individuals that, by assumption, are assumed to believe that these rules will not change. Then, an unexpected policy change (or announcement of a change) occurs and then individuals start re-optimizing

[7]In our view, a more useful classification is that distinguishing between i) measures addressed at controlling expenditures, and ii) changes in the sources of finances for pension expenditures.

[8]This proporion is 0 if the number of years of contribution is less than 15. It is 50% for 15 years of contribution and retirement at 65, and then increase (not linearly) up to 100% for 35 years of contribution and retirement at 65 years. The proportion falls by 6-8 p.p., (depending on personal circumstances and years of contribution) for each year of retirement before 65 years of age.

their behavior according to the new pension rules. Computation problems preclude that this re-optimization could be contemplated for individuals with many different employment histories. Thus, as an alternative, when considering the impact of reforms using individual life-cycle profiles, labour supply and labour demand effects are not really modelled, but included, if anything, by ad hoc assumptions.

Table 2 presents some results concerning the impact of extending the number of years used to compute pension benefits from the current level of 15 to 30. It draws, for the aggregate accounting approach, from Jimeno (2000), updating his results with the new demographic and labour market scenario. Sanchez-Martin (2001) and Diaz-Saavedra (2005) provide the analysis of this reform using the general equilibrium approach, while Jimeno (2003) does it under the individual life profile approach. For the first and third approaches, the results assume the baseline demographic and labour market scenarios (see Table 1), and an annual average growth rate of labor productivity of 2%.

The aggregate accounting approach and the individual life profile approach use the same demographic and labor market scenarios. The only difference between them is the consideration of heterogeneity and caps in benefits and contributions when computing the impact of the reform on average benefits. In the aggregate accounting approach, it is assumed that average benefits grow at the same rate that wages, and that wages grow at the same rate that GDP per worker. Thus, the only reduction in average benefits brought up by the reform arises from the fact that pension benefits are indexed to prices, rather than wages. This implies a reduction in the ratio of average benefit to GDP per worker of 4.5%. By simulating individual life profiles, we also considered the impact of caps on contributions and benefits and heterogeneity. As a result, the reduction in the ratio of average benefit to GDP per worker is 10%. This translates into a reduction of pension expenditures to GDP of about 1 p.p., in the first case, and 2 p.p., in the second. These results are in line with those reported in Da-Rocha and Lores (2005).

Using the general equilibrium methodology the results are slightly more pronounced. Sanchez-Martin (2001) and Diaz-Saavedra (2005) find that the percentage of GDP spent on pensions would be respectively 2 p.p. and 5 p.p lower than the case without pension reform. In both cases the incentives to early retirement are not substatially affected, and the main forces driving down the pension expediture over GDP is first, the lower pension levels to which individuals qualify, since now pension benefits are computed taking into account the earnings of the initial periods of the life-cycle which are those when individuals are less productive. And second, the fall in the tax rate needed to balance the aggregate government budget induces a higher level of output, since the capital stock increases as a result of both lower pension benefits and lower saving distorsions which, in the case of Diaz-Saavedra (2005) are associated with the sharp reduction in the consumption tax after the reform from 34.17% to 25.47%.

### Table 2: Approximating the effects of a change in the benefit computation formula*

| | Aggregate Accounting | General Equilibrium Models | | Individual life profile |
|---|---|---|---|---|
| | Jimeno (2000) | Sanchez-Martin (2001) | Diaz-Saavedra (2005) | Jimeno (2002) |
| | 2005 | 1997 | | 2005 |
| Pension Expenditures/GDP (%) | 9.0 | 15 | 15.3 | 9.0 |
| | 2050 | | | |
| Variation in $\frac{\text{average benefit per retiree}}{\text{GDP per worker}}$ | -4.5% | | | -10% |
| Pension Expenditures/GDP (%) | | | | |
| without reform | 19.6 | 27 | 28.5 | 19.6 |
| with reform | 18.7 | 25.2 | 23.1 | 17.7 |

(* The change considered is the rise in the number of years used for computation of the average contribution base entered into the benefit formula from the last 15 years of the working life to the last 30 years.)

# 6 Concluding remarks

Finally, we discuss in this section the features of the approaches that we think are important in order to properly assess the problem at hand, and the need of more empirical evidence concerning theses issues. A first important issue mentioned in the former sections is the difference between the general equilibrium approach and the others in accounting for possibly important feedbacks effects arising, for instance, from changes in taxes induced by demographic change. We think that a properly specified behavioral model of the joint determination of savings and labor supply in a life-cycle constext is needed so as to properly address the way in which the rules used to compute pension benefits, the demographic change and, in general, policy reforms may or may not affect the finances of the social security system. However, as utility-based general equilibrium models tend to enter very rapidly into the "curse of dimensionality" it may be reasonable to abstract from changes in prices, when assessing the effects of demographic change on pension expenditures. More so, if we consider the case of a small open economy. In any case, although in general the direction of the effect is not controversial and in fact it is a general modelling strategy, the importance of demographic changes for asset returns and financial markets is still a disputable issue, on which more empirical evidence is needed. In this sense, Yoo (1994) presents time series estimates of the relationship between asset returns and the age distribution and finds a statistically significant negative correlation bwteen the fraction of the U.S. population aged 45 to 54 and the returns of several types of assets. In contrast, more recently Poterba (2004) suggests that the results are in general sensitive to choices about the econometric specification.

A second relevant issue is the consideration of enough heterogeneity among individuals of the same generation. Since the pension formula depends on the labor market history of individuals, a suitable model should in principle account for some heterogenity along several dimensions, that could be modelled either deterministically or stochastically. For instance, heterogeneity in terms of education could in principle be modelled in a deterministic way, upon which there is no uncertainty. However, individuals should also face enough labor market risk and choose optimally labor supply along the life-cycle so as to properly study the way in which the features of the social security system affect that decision. For instance Lazear (1985) suggested that defined-contribution pension systems are more efficient in the sense that there is a close link between contributions and benefits that is taken fully into account by individuals when deciding how much work. In addition it is likely that the incentives created by the penalties for early retirement will be a function of accumulated financial wealth and social security entitlements. Jimenez (2005) has carefully study the monetary incentives for early retirement in Spain, although the estimation performed abstracts from financial wealth accumulation decisions. In addition, although his approach can incorporate very detailed sources of heterogeneity and consequently of explaining factors, they may not be very useful to address the welfare consequences of policy changes and the estimated relationships may not be necessarely stable. In addition, general equilibrium models (Sanchez 2001) do not find a significant effect of changes in the number of years used to compute pension benefits on the retirement pattern of older workers. Consequently, more microeconomic empirical evidence concerning these issues is clearly needed ir order to shed some light on the topic.

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