
Hugo Benítez-Silva†  J. Ignacio García-Pérez‡  Sergi Jiménez-Martín§

June 26, 2009

Abstract

In this paper we compare the importance of various policy instruments that can result in increased labor force participation by older workers. In the current economic and social environment, especially in the United States, older individuals are likely to extend their labor force participation beyond traditional retirement ages. Public policies can foster this behavior in order to reduce the financial pressures on the public social insurance systems. We explicitly consider the participation decision of older individuals, accounting for a number of sources of uncertainty including employment uncertainty, using a sequential decision structure. In particular we analyze the interplay between unemployment protection institutions (severance payments and unemployment benefits) and the public pension system.

We have numerically solved and simulated benchmark models of the sequential decision problem that individuals face in the United States and Spain, two countries with relatively similar public pension system structures but with marked differences in their employment and unemployment protection frameworks. We model in detail the incentive structure faced by individuals, and use administrative and household level data for the U.S. and Spain to empirically characterize the model in terms of the employment uncertainty, wage uncertainty, health uncertainty, and mortality uncertainty faced by individuals. We have found interesting and suggestive results. In the United States, the model is able to explain with great accuracy the strikingly high proportion of individuals who claim benefits exactly at the ERA, and the model is also able to replicate the increased hazard of applying for benefits at the NRA. In Spain, the model is considerably more complex than in the United States, given the need to account for the tenure and experience of individuals who reach retirement age as well as the possibility of receiving fairly large severance payments. However, we have been able to replicate with great success the fairly large proportion of Spaniards who apply early, age 60, and also the increased hazard at the NRA.

JEL Codes: J14, J26, J65

Keywords: retirement, employment uncertainty, severance pay, dynamic programming, U.S. vs. Spain

*We gratefully acknowledge the support from projects ECO2008-06395-C05-01 and SEJ2006-04803/ECON. The authors thank participants at ASAWM 2007 and SEVILLA for their helpful comments. The usual disclaimer applies.

†SUNY at Stony Brook, IAE(CSIC) and FEDEA
‡Universidad Pablo de Olavide, FCEA and FEDEA (jigarper@upo.es)
§Universitat Pompeu Fabra, and FEDEA. Department of Economics, Ramon Trias Fargas 25. 08005 BARCELONA (SPAIN). sergi.jimenez@upf.edu
1 Introduction and Motivation

Developed countries share a considerable concern about the financial sustainability of their social insurance systems. The origin of these worries can be found on two well documented processes: an unfavorable demographic performance, and a tendency towards reducing the age of retirement on those economies (see Gruber and Wise 1999). The former process has not improved in the last few years, especially in Europe, despite growing immigration, but the latter shows some signs of being affected by the recent trend, especially in the United States, towards higher labor force participation by older individuals. All this has motivated economists and policy makers to explore the links between the incentives set up by a wide variety of social insurance programs and retirement behavior. At the same time, multi-country studies are widely viewed as a rich source of variation, which can help understand policy effects that might seem puzzling when analyzed in the context of a single economy.

In the current economic and social environment, especially in the United States, older individuals are likely to extend their labor force participation beyond traditional retirement ages. Public policies can foster this behavior in order to reduce the financial pressures on the public social insurance systems. However, the models traditionally used to explain retirement behavior have ignored the unemployment risk and the available policies to cover such risk that can potentially reduce retirement incentives.

In our case we will explicitly consider in this paper the participation decision and job search activities of older individuals, accounting for unemployment uncertainty, by using a sequential decision structure. We consider that older individuals make participation decisions comparing the utility they receive from retirement or disability benefits today, with the expected utility from continuing active in the labor market. The participation decision, however, is subject to employment uncertainty, and if the likelihood of returning to the labor market after a period of unemployment is low, and the depreciation of expected retirement benefits is high, individuals will be more prone to choose to start receiving benefits as early as possible. Note that if the probability of becoming unemployed is ignored, the expected utility from work is overestimated and, hence, the probability of applying for benefits, especially at early ages, is underestimated. This mechanism can explain part of the striking shift of benefits claim from the Normal Retirement Age to the Early Retirement Age in the United States, and the widespread trend towards early retirement across many European countries, being Spain an archetypical example.

Social Security provides fairly complex incentives that affect the labor supply and benefit uptake behavior of individuals between the Early Retirement Age (ERA) and the maximum retirement age. These incentives are especially involved between the early and Normal Retirement Ages (NRA), and we analyze them in detail in the Appendix both for the US and Spain. In the former, two of the most important incentives are the Social Security Earnings Test (ET), which determines the maximum level of earnings that do not result in a benefit reduction for individuals who have claimed retirement benefits before the NRA, and the Actuarial Reduction Factor (ARF), which determines the permanent reduction in benefits that individuals face if they claim benefits early. However, the role of the Earnings Test in the context of the adjustment of the ARF is not very well understood, or even known by many. We will show through our dynamic model that the appropriate modeling of these incentives is key in order to understand the claiming behavior of Older Americans.

The different policy environments that can be found in many European countries and the United States, in particular in relation to employment and unemployment protection, are also a key feature of our model. Our main objective is to compare the US and the Spanish institutional framework regarding retirement and unemployment protection in order to evaluate the plausible implications of alternative designs of such institutions over individual decisions.

The model used in this paper is closely related to those presented in Rust and Phelan
(1997), Benítez-Silva, Buchinsky, and Rust (2003 and 2006), and Benítez-Silva and Heiland (2007). Our model also shares a number of characteristics with the work of French (2005), van der Klaauw and Wolpin (2008), and Blau (2008) among other researchers who solve, simulate, and in some cases estimate, dynamic retirement models under uncertainty. The importance of modeling in detail the incentive structure related to early retirement and claiming behavior has been convincingly emphasized by Benítez-Silva y Heiland (2007 y 2008), and Benítez-Silva et al. (2007). These researchers are the first to explain in the US context the trend towards early claiming, which has been documented using aggregate and administrative data in Benítez-Silva and Yin (2008). However, even in those complex models the authors ignore unemployment uncertainty, and assume a perfect control by the individual over its labor supply. Coile and Levine (2006) discuss the importance of taking into account unemployment uncertainty when analyzing retirement programs, but they do it within a reduced form context in which the discussion of possible reforms to the system is not meaningful, given that they do not explicitly model the behavior of the individuals or the incentives of the system.

Our research contributes to the vast retirement literature by paying special attention to unemployment uncertainty and the role that different sets of social insurance programs play in different countries, as a strategy to identify behavioral regularities that will allow us to analyze policy reforms in the United States and Europe. By carefully modeling unemployment uncertainty in a life-cycle model of retirement behavior, we correctly assess the trade-offs that individuals face when deciding whether to claim benefits early, and whether to drop from the labor force. The risk of unemployment is very important for old workers, whose productivity and grade of adequacy to new technologies tend to be lower as time passes. Hence, if we ignore the firing risk of old workers, we would be overestimating the utility workers derive from the option of continue working and, on the contrary, infra-estimating the option of exiting earlier from the labour market to retirement. Moreover, as it has been recently known (García-Pérez, 2006), the consideration of firing makes unemployed workers change their search behavior as their stage in unemployment is longer.

Our paper contributes also to the literature on search models by considering non-participation decisions in a non-stationary environment including the risk of dismissal. The possibility of non-participation in an otherwise standard search model was first analyzed in Pissarides (1976) and in Van den Berg (1990a). More recently, Frijters and Van der Klaauw (2006) estimates an structural, non-stationary search model with non-participation, where the state of inactivity (considered as an absorbing one) is unrelated to the economic conditions. Our analysis improves upon the former by considering the fundamental non-stationary induced by age considerations, and upon the latter by providing a full economic description of the non-participation state (i.e., retirement). Furthermore, we include in this literature the risk of dismissal and the possibility of receiving severance payments when fired. The only existing research about these issues is García Pérez & Sánchez-Martín (2008) where it is developed a search model with a full economic description of the non-participation state (i.e., retirement). the worker can have access to. The main novelty of the present paper with respect to the former is the consideration of severance payments for separated workers and also the allowance of saving decisions of workers.

Most researchers have spent relatively little time modeling the unemployment and re-employment probabilities, and the possibility of these influencing the retirement decisions have been left unexplored. Even some of the latest and more advanced work in this area (see for example Rust and Phelan 1997, and van der Klaauw and Wolpin 2008) pays relatively little attention to this issue. The price to pay for not considering the unemployment uncertainty is that the expected utility from continue to work is overestimated, and the probability of claiming early or applying for disability benefits is underestimated.

Our model carefully analyzes the job search decision, which is an important component of the re-employment probabilities. We build upon the recent work by Benítez-Silva (2000), and
García-Pérez (2006), to correctly assess the role that on-the-job-search, and search among the non-employed plays in a life-cycle model with unemployment uncertainty.

While our ultimate research objective is to estimate this model by Maximum Likelihood, and provide sensitivity analysis of its fit using Simulated Method of Moments, which might be considerably easier to estimate given the heterogeneity of the data sets we are using, in this paper we provide a partial equilibrium simulation exercise using calibrated parameter values. Most of these calibrated parameters are the result of extensive reduced form econometric models which have explored in detail the descriptive properties of the data, some other parameters like the discount factor and the relative risk aversion parameters are taken from the most recent studies using similar models.

From an empirical perspective, we use the predictions of our model to describe and understand some of the characteristics of the labor market for older workers who have access to early retirement provisions. We evaluate different policy changes in order to help older workers cope with the transition from unemployment to a new job in ages close to retirement and when different benefits are available. This objective is quite sensible in Europe where the labor force participation of those 55 to 64 is quite low, around 43.7%, compared with 78.4% for those 25 to 54. In fact, the European Union had set itself the target in the Lisboa Meeting in 2000 of reaching a participation of 50% among those over the age of 55.

We have been able to numerically solve and simulate benchmark models of the sequential decision problem that individuals face in the United States and Spain, and found interesting and promising results. In the United States, the model is able to explain with great accuracy the benefits claiming behavior of older Americans; namely, the strikingly high proportion of individuals who claim benefits exactly at the ERA, and the model is also able to replicate the increased hazard of applying for benefits at the NRA. In Spain, the model is considerably more complex than in the United States, given the need to account for the tenure and experience of individuals that reach retirement age as well as the possibility of receiving fairly large severance payments in case of being separated from their jobs. However, we have been able to replicate with great success (considering how elusive it has been for researchers using different methodologies) the fairly large proportion of Spaniards who apply early, age 60, and also the increased hazard at the NRA.

The structure of the paper is the following. After presenting the basic stylized facts regarding search and retirement both in the US and Spain in Section 2, we describe our dynamic programming model in Section 3. We describe the data sets we use for our simulation and estimation exercises in Section 4, and finally, we present our preliminary simulation results and conclusions in Section 5 and 6, respectively.

2 Previous literature and stylized facts regarding retirement

2.1 US facts

The large retirement literature developed during the 1980s and 1990s in the US has focused on explaining the connection between retirement incentives and retirement behavior.\(^1\) It concluded, quite convincingly, that the retirement peaks at age 62 and age 65 could be explained if the full set of incentives were included in the model. However, in the data used in those studies the majority of Americans were claiming benefits at age 65, while in the 1980s and 1990s the peak started to move towards age 62. By the end of the 1990s, almost 60% of older Americans were claiming benefits at age 62, and it has stayed at that level, even with the implementation of the 1983 Amendments that penalize early claiming of benefits and reward late claiming at a higher

\(^1\)For a survey of this broad retirement literature see Lumsdaine and Mitchell (1999). Hurd (1990), Lumsdaine (1995), and Ruhm (1996) provide good discussions of the earlier literature.
rate, along with the substantial increase in expected longevity since the 1970s. In fact, as of November 2007, 70.9% of men and 75.7% of women claimed Social Security benefits before the Normal Retirement Age (NRA), compared to 36% and 59% in 1970, respectively. Clearly, the economic incentives seem to be insufficient to achieve the objective of prolonging average work lives, given the strong correlation between benefit claiming and labor supply.

As it is clearly shown in Table 2, using data from Table 6.A4 of SSA’s Statistical Supplement, the take-up of retirement benefits at the earliest possible age has become prevalent in the US economy. The peaks are at the eligibility ages of 62 and 65 which comes as no surprise given this well established response to program incentives. Between 1994 and 2005, almost 60% of claimants have been taking their benefits at age 62, and between 15% and 20% wait for the normal age of retirement. A majority of the remaining individuals claim at age 63 or 64, with a very small proportion claiming after the NRA. The latter is worth emphasizing given that the Delayed Retirement Credit increased by half a percentage point every two years during this period. Notice the rather anomalous claiming behavior in 2000, which resulted in an increase in claiming at age 65, and a reduction of the proportion of individuals claiming at 62. This is driven by the large increase in new entitlements at age 65 and above in that year, very likely the product of the removal of the ET for those above the NRA, which made waiting to claim benefits because of a strong attachment to the labor force unnecessary. This conjecture is further supported by the evidence on benefits levels shown in the next bottom panel of this table. It shows the trends in benefits received, in dollars of 2005, as a function of the age at which benefits where claimed. We see a clear break in the patterns after 2000, especially in terms of the benefit levels at the NRA and above. In 1999 and 2000 later claiming led to consistently larger benefits, while the maximum benefit has been systematically obtained by those claiming at 65 since then. It drops sharply for those claiming after 65, potentially because those individuals are now of a type trying to catch up to compensate for a low wage career, or a sketchy one. Our interpretation of this evidence is that the removal of the ET for those above the NRA had the effect of allowing people to claim benefits independently of their labor supply behavior, leading relatively well-off individuals, who before waited to claim to avoid the ET, to claim sooner. Those claiming after the NRA are now either individuals trying to catch up after relatively lower wage career profiles, or spouses claiming on their partner’s earnings histories. Notice that the scheduled increases in the NRA are essentially bringing back the old ET for those above age 65, so the prediction is that a pre-ET-reform benefit level distribution is likely to emerge, at least in part, in the next years. It is important to emphasize that this table does not account for the actuarial reduction of benefits faced by individuals claiming before the NRA, or for the delayed retirement credit obtained by those after the NRA. In this research we are interested in the inflation-adjusted level of benefits actually received by claimers since this is what our dynamic model of retirement predicts. 

2.2 Spanish facts and data

For Spain, we can find a relatively large body of literature studying the financial implications of the ageing process. However, the incentive literature is more scarce. Boldrin et al. (1999) and Jiménez-Martín and Sánchez-Martín (2004) computed public pension accruals and implicit tax rates for some selected representative agents. The first paper mentioned shows that low-income workers have very few incentives to stay active at the ERA (60 in Spain), in sharp contrast with the situation for average income workers. The authors conjecture that the minimum pension is

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3It is clear that analyzing the role of (theoretically) actuarially fair adjustments is important to understand the importance of individual heterogeneity in claiming behavior. Benítez-Silva and Yin (2008) focus on this point and find considerable individual heterogeneity in benefits receipt, especially for those above the NRA.
behind this phenomenon, a fact confirmed in the second paper mentioned. Offering support to the works mentioned above, Boldrin et al. (2004), estimated a reduced form model for evaluating retirement incentives, and, finally, Blanco and de la Rica (1999) estimates durations model for early retirement. More recently applied works follow a more structural approach, for example Jiménez-Martín and Sánchez-Martín (2007) solved and estimated a life-cycle model of retirement in order to analyze the effect of minimum pension. Díaz-Giménez and Díaz Saavedra (2009) have calibrated a very realistic retirement model. Finally, García-Pérez and Sanchez-Martín (2008) have analyzed a retirement model with search frictions. All these paper shows that incentives matter in retirement decisions.

In the case of Spain, we use the *Muestra Continua de Vidas Laborales (MCVL)* for getting the basic features of the retirement system. This is an administrative data set based on a random draw from the Social Security archives. It contains a sample of 4% among all the affiliated workers, working or not, and pensioners in the year 2006-2007. It has information about 1,1 million people which covers their entire labor history and, for pensioners, it offers also the main parameters to calculate their pension. The main characteristics of this dataset will describe afterward.

Table 3 presents the distribution of the take-up rate as well as the implied average benefits using data from the MCVL in the period 1991 to 2007. As in the U.S. case and for similar reasons, the peaks at the early retirement age (60 in the Spanish Case) and normal retirement age (NRA, 65) are evident. The decline, as compared to early 90’s, of the take-up rate at age 60 is explained by the overall economic improvement of the Spanish economy that has been observed since 1996. Retirement at intermediate ages (61 to 64) has mildly increased in the last few years due to the introduction of two programs: Partial retirement and Special Retirement at age 64. Finally, after some increase in the take-up rate in the late 90’s and early 2000’s, retirement at age 65 has remain stable in the last few years.

The distribution of average benefits by age is very revealing. Despite the strong penalty implied by early retirement (between 30 and 40 percent, depending on the year and the number of years of contribution), average benefits at age 60 are not lower that they are at age 65. In fact, the highest values of average benefits are observed, depending on the year, at ages 63 and 64. This implies that there is a large proportion of high earners that retire at age 60, mainly because of the use of special early retirement programs.

Table 4 presents the sample distribution by job tenure or time in unemployment, age, and skill level. In all cases we use data from the MCVL corresponding to year 2007. At advanced ages, the sample distribution by job tenure is very similar for both skilled and unskilled workers. It is concentrated between 1 and 11 years (around 65 percent of the cases at age 60 for both skilled and clerical-unskilled workers), and it decreases mildly from 12 years of tenure. The distribution by time unemployed is also very similar for skilled and clerical-unskilled workers. From age 55 on, the fraction of long-term unemployment increases with age for both groups, evidencing the sharp decline of reemployment probabilities after age 50. Without much doubt, the existence of specific UB programs for workers aged 50 and above helps explain this fact.

### 3 Methodology and the Dynamic Model

We propose to solve, simulate, and estimate, an extended version of the Life-Cycle model. In our version of this model individuals maximize expected discounted life-time utility, which in this case depends on consumption and leisure, and individuals face an array of incentives from social insurance programs: retirement incentives, disability insurance, and unemployment insurance.

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*The Partial retirement program allows the worker to combine work and pension incomes at a rate that varies from 25-75 to 15-85, respectively. Before age 65 it requires the substitution of the retiring worker by an unemployed younger worker by means of hand-over contracts.*
We formally acknowledge that individuals face several sources of uncertainty, including life-time uncertainty, wage uncertainty, health uncertainty, and unemployment uncertainty. The latter is one of the keys of our model, since individuals know that as they grow old, and their productivity declines, the probability of losing their jobs might be increasing, and their probability of re-employment might be decreasing. This can have a sizable effect on how they assess the benefits provided by early retirement provisions, and even disability benefits.

3.1 The Dynamic Model

The model will be solved using Numerical Dynamic Programming techniques based on backward induction starting in the last period of life, that we define as $T$. We provide an individual level analysis. We focus, for the moment, on male respondents although we will consider extensions to include females, and, eventually, we will analyze couples’ decisions.

We assume that individuals maximize the expected discounted stream of future utility, where the per period utility function $u(c, l, h, t)$ depends on consumption $c$, leisure $l$, health status $h$, and age $t$. We specify a utility function for which more consumption is better than less, with agents expressing a moderate level of risk aversion. The flip side of utility of leisure is the disutility of work. We assume that the utility (disutility of work) is an increasing function of age, is higher for individuals who are in worse health than individuals who are in good health, and is lower for individuals with higher human capital measured by the average wage. In addition, we assume that the worse an individual’s health is, the lower their overall level of utility is, holding everything else constant. Moreover, we assume that individuals obtain utility from bequeathing wealth to heirs after they die. This model assumes that individuals are forward looking, and discount future periods at a constant rate $\beta$, assumed in our calibration exercises to be equal to 0.96.

We solve the dynamic life-cycle model by backward induction, and by discretizing the space for the continuous state variables.5 The terminal age is 100 and the age when individuals are assumed to enter the labor force is 21. Prior to their 62nd birthday (60th in Spain), agents in our model make a leisure and consumption decision in each period. At 62 (60 in Spain) and until age 70, individuals decide on leisure, consumption, and application for retirement benefits, denoted $\{l_t, c_t, ssd_t\}$, at the beginning of each period, where $l_t$ denotes leisure, $c_t$ denotes consumption, which is treated as a continuous decision variable, and $ssd_t$ denotes the individual’s Social Security benefit claiming decisions. We assume two possible values for $ssd_t$. If $ssd_t$ equals 1 the agent has initiated the receipt of benefits. If the individual has not filed for benefits or is not eligible then $ssd_t$ is equal to 0.

After age 70 it is assumed that all individuals have claimed benefits, and again only consumption and leisure choices are possible. Leisure time is normalized to 1, where $l_t = 1$ is defined as not working at all, $l_t = .543$ corresponds to full time work, and $l_t = .817$ denotes part-time work. These quantities correspond to the amount of waking time spent non-working, assuming that a full-time job requires 2000 hours per year a part-time job requires 800 hours per year.

The model allows for four different sources of uncertainty: (a) lifetime uncertainty: modeled to match the Life Tables of the United States or Spain with age and health specific survival probabilities; (b) wage uncertainty: modeled to follow a log-normal distribution, function of average wages as explained in more detail below; (c) health uncertainty: assumed to evolve in a Markovian fashion using empirical transition probabilities from a variety of household surveys, including the NLSY79 and the HRS in the USA and the ECHP in Spain.6 And finally (d) Unemployment uncertainty: modeled following the empirical distributions using the CPS from 1989 to the present in the case of the United States and the MCVL in Spain.

5See Rust (1996), and Judd (1998) for a survey of numerical methods in economics.
6See below for a complete descriptions of these datasets.
Given that we allow for unemployment uncertainty and therefore the possibility of losing a job, it is quite important to model the severance pay the individuals may receive. In the United States this is a relatively minor issue, since there is no legally established level of severance pay the employers need to provide, and the standard two-weeks pay is not a function of tenure on the job, which is quite convenient to maintain the size of problem as small as possible. However, in Spain (and a number of other European countries) this is a very important issue and one of the keys of our model.

First, the fact that the level of severance pay is a function of tenure forces us to account for tenure as a state variable in the model. In Spain it is quite standard for workers to receive a month pay for every year of work with an employer, and many times (sometimes awarded by a judge after suing the employer) even a month and a half per year worked, with a maximum of three and a half years of pay. Using the maximum allowed by the law for ordinary contracts (the month and a half per year of work) we would then need to carry up to twenty eight tenure levels on top of the values reflecting no tenure due to recent firing. To reduce the size of the state space, which is especially large in the Spanish case, we have decided to only model a total of eleven values for the tenure variable. We first allow individuals to accumulate a maximum of eight years of tenure, and if they are fired after those eight years they get a severance pay level equal to one year of average wages if they have total accumulated experience of less than 16 years. If the accumulated experience is between 16 and 28 years then they get a severance pay equal to two years of average wages, and if they have an accumulated experience of 28 years or more they get the maximum allowed by the law for older Spanish cohorts which is three and a half times the average wage. This simplification likely leads to an overestimation of the severance pay given to some individuals who in spite of having considerable accumulated experience may have had some spell out of work. However, given the bend points chosen for some individuals the severance pay might actually be underestimated.

Additionally, we allow for a tenure level of zero for individuals who have never worked or just got fired, a tenure level that we label as nine for those who could not find a job after a period out of work, and a tenure level that we label as ten for those who did not find a job after two periods out of work. The reason we make the latter distinctions is because in Spain the long-term unemployed (those unemployed for more than two years) receive a lower level of unemployment benefits than those recently unemployed.

The tenure variable is also useful to model the unemployment benefits received by workers in Spain. Individuals can receive up to two years of unemployment benefits (receiving approximately 65% of their average wage). if they have accumulated six years of tenure. Each year of tenure gives you the right to receive four months of benefits.

Interestingly, the fact that we model tenure endogenously in the Spanish case, allows us to characterize different unemployment probabilities by tenure level following the empirical distributions we observe in the administrative data from the MCVL. For example, in Spain, the unemployment and re-employment probabilities are markedly different depending on the employment history, in part due to the fixed-term or temporary contracts typically used in Spain, where only after three years on the job the workers gains a more permanent position in the company. Following the information we obtain in the data, we allow for different unemployment probabilities depending on whether the person has one, two, three, four to six, or seven or more years of tenure, and we allow also for different re-employment probabilities for individuals

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7Since the 1997 labor market reform, it is also possible to hire a worker under a new permanent contract whose severance payments are equal to 33 days per year of work, with a maximum of two years of pay.

8Individuals receive a severance pay which is a function of average wages and not wages, since we do not carry the latter as state variables in the model in order to reduce the state space which would otherwise be almost intractable.

9The 65% we use is a simplified version of the real design of the policy which is offering 70% of the previous wage during the first six months in unemployment and 60% from the seventh month onwards.
who have been recently fired, those who have been out of work for two years and those with unemployment duration being three years or more. This introduces in the model a great deal of heterogeneity which will serves us well to match the data in several important dimensions.

Figure 1 presents the dismissal and re-employment probabilities used in our calibration exercise. We can see in this figure their distribution by tenure (or duration of the unemployment spell) and also by skill level (White Collars and Clerical & Blue Collars jointly). The dismissal probability, besides its high levels for workers aged less than 25, mildly increases with age up to age 60, and decreases afterwards (because the retirement option becomes available). This pattern is observed regardless of the skill level, although the firing probability is lower for skilled workers for all tenure levels. Alternatively, the dismissal probability significantly decreases with the level of tenure in the job. Especially important is the jump from one to two years of tenure. Reemployment probabilities decrease with age and the duration of the unemployment spell. Specially important is the rate of decay after age 50, which nearly doubles the one before this age.

The state of an individual at any point during the life cycle can be summarized by five state variables in the US version of the model: (i) Current age $t$; (ii) net (tangible) wealth $a_t$; (iii) the individual’s Social Security benefit claiming state $ss_t$; (iv) the individual’s health status, and (v) the individual’s average wage, $\bar{w}_t$. This average wage is a key variable in the dynamic model, serving two roles: (1) it acts as a measure of permanent income that serves as a convenient sufficient statistic for capturing serial correlation and predicting the evolution of annual wage earnings; and (2) it is key to accurately model the rules governing payment of the Social Security benefits. In the US, an individual’s highest 35 years of earnings are averaged and the resulting Average Indexed Earnings (AIE) is denoted as $\bar{w}_t$. The PIA is the potential Social Security benefit rate when retiring at the NRA. It is a piece-wise linear, concave function of $\bar{w}_t$, whose value is denoted by $P(\bar{w}_t)$. In the case of Spain, the average wage is a function of the previous 15 years of earnings.

In principle, one needs to keep as state variables the entire past earnings history for the US case, and a fairly long history for Spain. To avoid this, we follow Benítez-Silva, Buchinsky, and Rust (2006) and approximate the evolution of average wages in a Markovian fashion, i.e., period
$w_{t+1}$ average wage, $\bar{w}_{t+1}$, is predicted using only age, $t$, current average wage, $w_t$, and current period earnings, $y_t$. Within a log-normal regression model, we follow Benítez-Silva, Buchinsky, and Rust (2006), such that:

$$\log(\bar{w}_{t+1}) = \gamma_1 + \gamma_2 \log(y_t) + \gamma_3 \log(w_t) + \gamma_4 t + \gamma_5 t^2 + \epsilon_t. \quad (1)$$

The $R^2$ for this type of regression is very high, with an extremely small estimated standard error, resulting from the low variability of the $\{\bar{w}_t\}$ sequences. This is a key aspect of the model given the important computational simplification that allows us to accurately model the Social Security rules in our DP model with minimal number of state variables. For Spain we follow a very similar methodology but we additionally introduce as explanatory variables experience and experience squared, which we need to have as state variable anyway to properly compute retirement benefits, and also severance payments in this European country.

We then use the observed sequence of average wages as regressors to estimate the following log-normal regression model of an individual’s annual earnings:

$$\log(y_{t+1}) = \alpha_1 + \alpha_2 \log(w_t) + \alpha_3 t + \alpha_4 t^2 + \eta_t. \quad (2)$$

This equation describes the evolution of earnings for full-time employment. Part-time workers are assumed to earn a pro-rata share of the full-time earnings level (i.e., part-time earnings are $0.8 \cdot \frac{800}{2000}$ of the full-time wage level given in equation (2)). The factor of 0.8 incorporates the assumption that the rate of pay working part-time is 80% of the full-time rate. Again, in the Spanish case we also account for experience and experience squared in the equation.

The advantage of using $w_t$ instead of the actual Average Indexed Earnings, especially in the US, is that $\bar{w}_t$ becomes a sufficient statistic for the person’s earnings history. Thus we need only keep track of $\bar{w}_t$, and update it recursively using the latest earnings according to (1), rather than having to keep track of the entire earnings history in order to determine the 35 highest earnings years, which the AIE requires. In Spain things are a bit trickier; On the one hand, the construction of the average wage does provide a very convenient way of summarizing the wage history, but the Spanish benefits rules explicitly vary by the experience of the individual at the time they reach retirement age. It is only when an individuals has accumulated 40 years of experience and claims at the NRA that he or she receives their full PIA. Interestingly, the PIA in Spain is not a progressive function of the average wage, but just the average wage itself. The Spanish system requires a minimum of 15 years of experience to receive benefits, and for every year that the individual falls short of the 40 years of experience the benefits are reduced by about 2%. This feature of the incentive structure forces us to keep track of experience as a state variable, making the state space considerably larger than in the US case.

We assume that the individual’s utility is given by

$$u_t(c, l, h, t) = \frac{c^{\gamma} - 1}{\gamma} + \phi(t, h, \bar{w}) \log(l) - 2h, \quad (3)$$

where $h$ denotes the health status and $\phi(t, h, \bar{w})$ is a weight that can be interpreted as the relative disutility of work. We use the same specification for $\phi$ and the disutility from working as in Benítez-Silva, Buchinsky, and Rust (2006). The disutility of work increases with age, and is uniformly higher the worse one’s health is. If an individual is in good health, the disutility of work increases much more gradually with age compared to the poor health, or disabled health, states. The disutility of work decreases with average wage. We postulate that high wage workers, especially highly educated professionals, have better working conditions than most lower wage blue collar workers, whose jobs are more likely to involve less pleasant, more repetitive, working conditions and a higher level of physical labor.

We assume that there are no time or financial costs involved in applying for retirement benefits. The parameter $\gamma$ indexes the individual’s level of risk aversion. As $\gamma \to 0$ the utility
of consumption approaches \( \log(c) \). We use \( \gamma = -0.37 \), which corresponds to a moderate degree of risk aversion, i.e., implied behavior that is slightly more risk averse than that implied by logarithmic preferences.

Thus, the expected present discounted value of utility from age \( t \) onward for an individual with state variables \((a, \overline{w}, ss, tn_{t-1}, Ex_t)\) where \( a \) stands for assets, is represented by the following two Bellman equations that correspond to the core of the model we are analyzing. We separate the value of being employed and the value of being unemployed. In the notation below we are presenting the state variables applicable to the Spanish case, for the US we drop tenure and experience from the model. One of the keys of the model is that we are adding the probability of losing a job to a dynamic life cycle model of consumption, asset accumulation and retirement.

**The value of being employed**

\[
V^I_{1,\tau}(a, \overline{w}, ss, tn_{t-1}, Ex_t) = \max_{c_t, \tau, ssd} U(c_t, L_{\tau,t}) + \\
\beta \left[ (1 - \delta) \text{E} \max (V^{t+1}_{1,\tau}(x), V^{t+1}_{0,\tau}(x)) + \delta V^{t+1}_{0,\tau} \right] 
\]

subject to,

\[
L_\tau = L(1 - I_\tau) + I_\tau \\
a_{t+1} = (1+\tau)(a_t - c_t) + (w_t + \delta FC_t)(1 - I_\tau) + I_\tau P_t
\]

**The value of being unemployed**

\[
V^I_{0,\tau}(a, \overline{w}, ss, tn_{t-1}, Ex_t) = \max_{c_t, \tau, ssd} U(c_t, 1) + \\
\beta \text{E} \max (V^{t+1}_{1,\tau}(x), V^{t+1}_{0,\tau}(x))
\]

\[
L_\tau = L(1 - I_\tau) + I_\tau \\
a_{t+1} = (1+\tau)(a_t - c_t) + b_t(1 - I_\tau) + I_\tau P_t
\]

As explained before, the severance pay, \( SP_t \), in Spain are computed as a function of tenure and average wages, and unemployment benefits, \( b_t \), consider the same variables and also unemployment duration. Thus, we define:

\[
FC_t = f(tn_{t-1}, \overline{w}) 
\]

\[
b_t = f(tn_{t-1}, \overline{w}, d_t)
\]

The function \( EV_{t+1}(a, \overline{w}, ss, c, l, ssd, h, tn, Ex) \) in each of the two labor status denotes the conditional expectation of next period’s value function, given the individual’s current state \((a, \overline{w}, ss, tn_{t-1}, Ex_t)\) and decisions \((c, l, ssd)\). Specifically, we have
For the moment we do not model the institutional details of private pension schemes or disability insurance. However, we do model private savings.

At least one job offer is received in every period. Individuals decide to accept or not the offer, and even if they accept the offer they could be displaced before they start to work that period. We do not differentiate here between someone who continues to work in a given job, and someone who changes jobs without a period out of the labor market. This assumes implicitly the portability of the accumulated tenure, a feature believed to be widely available to high skill individuals in Spain.

There is, at least, a period of unemployment after displacement.

The unemployment probability \( \delta \) is a function of the characteristics of individuals like tenure and age.

For the moment we do not model the institutional details of private pension schemes or disability insurance. However, we do model private savings.

We assume an initial level of assets in the first period, \( a(0) = a_0 \), and assume they face borrowing constraints, \( a(t) \geq 0 \) for every \( t \geq \tau \).

\[
EV_{t+1}(\cdot) = \int \sum_{y} \sum_{h'=0}^{2n} \sum_{ss'=0}^{11} \sum_{tn'=0}^{40} V_{t+1}(wp_t(a, \overline{w}, y', ss, ssd), awp_t(\overline{w}, y'), ss') \\
\times f_t(y'|\overline{w})k_t(h'|h)g_t(ss'|a, \overline{w}, ss, ssd)q_t(tn'|tn, l)\alpha_t(Ex'|Ex, l)dy',
\]

where the number of Social Security states \( n \) is nine for the United States and eleven in the case of Spain. Additionally, \( awp_t(aw, y) \) is the Markovian updating rule that approximates Social Security’s exact formula for updating an individual’s average wage, and \( wp_t \) summarizes the law of motion for next period’s wealth, that is,

\[
wp_t(a, \overline{w}, y, ss, ssd) = R\left[a + ssb_t(\overline{w}, y', ss, ssd) + y' - \tau(y', a) - c\right], \tag{11}
\]

where \( R \) is the return on saving, and \( \tau(y, a) \) is the tax function, which includes income taxes such as Federal income taxes and Social Security taxes and potentially other types of state/local income and property/wealth taxes. The \( awp_t \) function, derived from (1), is given by

\[
awp_t(aw, y) = \exp\left\{ \gamma_1 + \gamma_2 \log(y) + \gamma_3 \log(aw) + \gamma_4 t + \gamma_5 t^2 + \sigma^2/2 \right\}, \tag{12}
\]

where \( \sigma \) is the estimated standard error in the regression (1). Note there is a potential “Jensen’s inequality” problem here due to the fact that we have substituted the conditional expectation of \( w_{t+1} \) into the next period value function \( V_{t+1} \) over \( w_{t+1} \) and \( aw_{t+1} \) jointly. However, as noted above, the \( R^2 \) for the regression of \( aw_{t+1} \) on \( aw_t \) is virtually 1 with an extremely small estimated standard error \( \hat{\sigma} \). In this case there is virtually no error resulting from substituting what is an essentially deterministic mapping determining \( aw_{t+1} \) from \( w_{t+1} \) and \( aw_t \).

Above, \( f_t(y'|\overline{w}) \) is a log-normal distribution of current earnings, given current age \( t \) and average wage \( \overline{w} \), that is implied by (2) under the additional assumption of normality of errors \( \eta_t \). The discrete conditional probability distributions \( g_t(ss'|a, \overline{w}, ss, ssd) \) and \( k_t(h'|h) \) reflect the transition probabilities in the Social Security and health states, respectively. Additionally, \( q_t \) and \( \eta_t \) are the discrete probability distributions which reflect the transition probabilities in the tenure and experience states, respectively.

Some additional assumptions implicit in our Dynamic Programming are:

- A period of employment (at least) follows the decision to work from unemployment or from the current job (after accepting a job offer), if displacement does not occur.

- At least one job offer is received in every period. Individuals decide to accept or not the offer, and even if they accept the offer they could be displaced before they start to work that period. We do not differentiate here between someone who continues to work in a given job, and someone who changes jobs without a period out of the labor market. This assumes implicitly the portability of the accumulated tenure, a feature believed to be widely available to high skill individuals in Spain.

- There is, at least, a period of unemployment after displacement.

- The unemployment probability \( \delta \) is a function of the characteristics of individuals like tenure and age.

- For the moment we do not model the institutional details of private pension schemes or disability insurance. However, we do model private savings.

- We assume an initial level of assets in the first period, \( a(0) = a_0 \), and assume they face borrowing constraints, \( a(t) \geq 0 \) for every \( t \geq \tau \).
3.2 Solving and Simulating the Model

Our interest in solving, simulating, and eventually estimating a model with the level of complexity we have described is twofold. On the one hand, the model will be able to provide a variety of predictions which we can then compare with the data, like the length of employment spells, the length of unemployment spells, and the average tenure on the job. Additionally, the model will provide a set of structural parameters which are the foundations of the model even when we change the incentive structure to analyze the effect of policy changes on the behavior of individuals.

While the modeling of the incentive structure in the US is quite involved but fairly well described by a number of researchers, the problem gets particularly complex for the case of Spain, mainly because of the large number of details of the model and the many reforms that the system has undergo in the last decades. The additional complication is the complex structure linked to unemployment benefits and severance pay systems that protect employment. As we have described above, due to the these complications, we are forced in the Spanish case to include two additional state variables, experience and tenure, which increases the size of the dynamic problem for Spain by an order of 400. Clearly, by having to account in some detail for the history of employment and the history of work with a given employer introduces non-Markovian features in the model, which unavoidably lead to large increases in the size of the problem analyzed.

As explained earlier, our model allows for four different sources of uncertainty. The random draws to simulate these sources of uncertainty will be the same for all the models compared in the following, such that the differences presented in the results are only due to the changes in the incentive schemes. Underlying these characterization of uncertainty is the assumption that agents behave rationally given the information they have about the future (stochastic) evolution of these state variables.

The state of an individual at any point during the life cycle can be summarized by five state variables in the US version of the model: (i) Current age \( t \); (ii) net (tangible) wealth \( a_t \); (iii) the individual’s Social Security benefit claiming state \( ss_t \); (iv) the individual’s health status, and (v) the individual’s average wage, \( w_t \). For the Spanish version we have to allow for two more state variables: experience, \( Ex_t \), in order to properly characterize the complex retirement scheme set up in the Spanish law (See Appendix), and tenure, \( tn_t \), which as explained above is the key to properly model the structure of severance pay and unemployment benefits in Spain. These two additional state variables make the size of the problem for the Spanish case considerably larger, given that experience is modeled with 40 different values to reflect that only those with forty or more years of experience receive their full retirement benefits level, and tenure is modeled taking 11 different values. For computational simplicity, we assume that decisions are made annually rather than monthly, but we allow for the benefit adjustments due to earnings above the Earnings Test limit in the US case to happen semi-annually.

4 The Data and Some Cross Country Comparisons

We will use the six available waves of the HRS, which cover the 1992 to 2002 period of the US economy. The HRS is a nationally representative longitudinal survey of 7,700 households

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10 For the US case, this translates into a problem with over half a million states in which to solve the model (80 periods, 15 discretized wealth states, 8 discretized average wage states, 3 health states, and 18 Social Security states). We are able to solve this model and simulate it 10,000 times using Gauss, and exploiting its capability to link dynamic libraries written in C by the authors and some of their co-authors. These C libraries perform over 95% of the computations involved in solving and simulating these models. For the case of Spain the case is considerably larger, and results in the solution in nearly 100 million states. The code used for these simulations is available upon request, and will eventually be available on the web.
headed by an individual aged 51 to 61 as of 1992-93. The primary purpose of the HRS is to study the labor force transitions between work and retirement with particular emphasis on sources of retirement income and health care needs (see Juster and Suzman 1995). Most of our work uses the public releases of the data, but in the future we will request access to the restricted data on earnings in order to construct the measures of Social Security wealth.

In the case of Spain, we will use the *Muestra Continua de Vidas Laborales* for getting the basic features of the retirement system. This is an administrative data set based on a random draw from the Social Security archives. It contains a sample of 4% among all the affiliated workers, working or not, and pensioners in the year 2006. It has information about 1.1 million people which covers their entire labor history and, for pensioners, it offers also the main parameters to calculate their pension. The main characteristics of this dataset will describe afterward.

This database offers information about the personal characteristics of the worker and also about all her employment spells throughout her labor history. We have information about age, gender, occupation, unemployment and employment spells and their respective exact durations. We have available the reasons for each contract ending, the geographical location of the job, the firm’s sector of activity and the type of contract held. Moreover, we have exact information about wages, measured as the “base de cotización” (contribution base) which coincides with the monthly wage for all workers that earn more than the minimum base and less than the maximum one. These two limits are annually decided by Social Security authorities and make the wage to be censored in cases where it is outside these limits.

We use the eight waves of the Spanish part of the European Community Househeld Panel (ECHP), in order to calibrate the health shocks in this economy during the 1994-2001 period. The ECHP is an annual longitudinal survey that covers 14 countries members of the European Union. It is coordinated by the Statistical Office of the EU, and covers demographics, labor force behavior, income, health, education, etc. The objective of the ECHP is to represent, both cross-sectionally and longitudinally, the population of the EU at the level of households and individuals. The sample size ranges from around 1,000 households for Luxembourg, to over 8,000 for Germany.

The first wave of the ECHP was conducted in 1994, and wave eight was in the field in 2001. One of the attractive features of the ECHP for socio-economic research is its comparability across countries and over time (see Sergi Jiménez-Martín et al. 1999, and Peracchi 2002).

5 Simulation Results

Table 5 presents the simulations for the case of the U.S. We show three panels of results, with the first panel using a benchmark model without unemployment uncertainty, and with a simplified characterization of the Earnings Test. As discussed in great detail in Benítez-Silva and Heiland (2007, 2008), and also in Benítez-Silva et al. (2008) most of the retirement literature has modeled the earnings test as a tax. However, this is incorrect, and distorts the incentive structure in the direction of making early claiming less attractive. This first panel shows that while the model presents a claiming peak at 62, it is much smaller than in the data. The second panel presents the case in which we properly model the incentive structure of the earnings test, and this time the claiming peaks are much closer to what we see in the data, convincing us of the need to account for the full incentive structure to characterize optimal behavior in line with the empirical facts. Finally, the third panel presents our full model, in which we introduce employment uncertainty. The model improves further, and we now find a distribution of claiming ages very close to the aggregate data reported by the U.S. Social Security Administration.

These findings for the U.S. are no small accomplishment given how elusive has been for researchers to explain the claiming behavior of Americans in the last decade. Notice that we accomplish this excellent fit without relying on heterogeneous preferences or hard to test beliefs.
about the future. Regarding labor supply, the qualitative results are promising, showing a declining labor supply at older ages, but the quantitative fit will require additional work in the empirical characterization of the wage process and the initial conditions faced by the agents.

Table 6 shows some preliminary results of the simulations for the Spanish case. As explained above solving and simulating this model is considerably more challenging than for the U.S., given the need to account for additional state variables, and the need to model a more complex incentive structure regarding retirement, employment uncertainty, and employment protection. The main challenge for researchers of the retirement incentive structure in Spain has been to replicate the fairly large retirement peaks at age 60 and 65, in a world in which health insurance is public and the legislation is less than clear about the penalties and rules associated with early retirement provisions. The table shows again three panels, and in this case in much more striking fashion than in the U.S. we see that we very much need to account for the full incentive structure to be able to capture the fairly large peak we observe in the data at age 60. In fact our current version of the model overshoots the proportion of individuals who claim at age 60, which in the most recent data is closer to 40%. We believe the reason for this discrepancy lies on the complexities of characterizing the severance pay as a function of tenure, while maintaining a manageable size of the state space.

As explained in the previous sections, we have decided to allow individuals to only accumulate up to 8 years of tenure, while strictly speaking we would need to account for up to 28 to fully characterize the kind of severance pay received by Spanish workers when dismissed. Instead of increasing the state space in a way that would make it almost intractable at this time, we have chosen to assume that conditional on reaching tenure 8, individuals face a stochastic shock which will determine their tenure for the purposes of severance pay following the empirical tenure distribution for those who reach tenure 8 in our administrative data form the MCVL. This allows us to introduce heterogeneity in the severance pay as a function of tenure, but save on the number of states we have in the model.

We believe that this strategy allows us to walk in a fairly convincing way the line between generality of the model and the very much needed parsimony in structural stochastic dynamic models of individual behavior.

6 Policy Experiments

In this section we present the simulation results from various policy experiments we have set for the U.S. and Spanish case. In either case we simulate the labor supply consequences as well as the foreseeable impact on the Social Security accounts.

For the U.S. we plan to simulate the introduction of an Europe-like employment protection system. In particular, we first simulate the introduction of a one-month severance payment for each year of tenure up to 24 year. We also simulate the consequences of introducing a more generous unemployment benefits. We finally simulate the combination of both cases.

For Spain we simulate just the opposite case: the introduction of a more flexible labor market, with less employment protection. We first simulate a small fix severance payment. Say, for example, one month severance payment. We also evaluate for the Spanish case the separation of the claiming and retirement decisions combined with the introduction of an earning test in the spirit of the US case. We finally simulate the combination of all three changes altogether.

All these simulations, although specific for the US and the Spanish cases, will allow a better assessment of a number of reforms in the United States, and many European countries directed precisely at affecting the labor supply and claiming decisions of older workers.

[TO BE COMPLETED]
7 Conclusions and Discussion

[TO BE ADDED]

References


https://s044a90.ssa.gov/apps10/poms.nsf/aboutpoms.


Appendix US: Social Security Incentives for Early Retirement

Individuals who claim benefits before the NRA but continue to work or reenter the labor force can reduce the early retirement penalty by suspending benefit payments. The Actuarial Reduction Factor, ARF, (or early retirement reduction factor), in turn, will be increased proportionally to the number of months without benefits, which will increase benefits permanently after the individual reaches the NRA. This adjustment of the ARF allows those who become beneficiaries before the NRA to partially or completely reverse the financial consequences of their decision, averting being locked-in at the reduced rate. In the sequel of this section the exact details of these incentives are presented.

Benefit Calculation

Individuals aged 62 or older who had earned income that was subject to the Social Security payroll tax for at least 10 years since 1951 are eligible for retirement benefits under the Old Age benefits program (OA program). Earnings are subject to the tax up to an income maximum that is updated annually according to increases in the average wage. To determine the monthly benefit amount (MBA), the Social Security Administration calculates the Primary Insurance Amount (PIA) of a worker as a concave piece-wise linear function of the worker’s average earnings subject to Social Security taxes taken over her 35 years of highest earnings. If the benefits are claimed at the NRA (66 for those born between 1943 and 1954, and currently at 65 and 8 months), the MBA equals the PIA. If an individual decides to begin receiving benefits before the NRA and exits the labor force or stays below the earnings limit, her MBA is reduced by up to 25%, assuming a NRA of 66. Under the current regulation of the OA program, the monthly benefit amount received upon first claiming benefits depends on the age (month) of initiation of Social Security benefits, in the following way,

\[
MBA_t = \begin{cases} 
(0.75 + 0.05 \times \frac{1}{12} \times (MP3Y)) \times PIA, & \text{if claimed more than 3 years before NRA;} \\
(0.80 + 0.20 \times \frac{1}{36} \times (M3Y)) \times PIA, & \text{if claimed within the 3 years before NRA}
\end{cases}
\]

where \(MBA_t\) represents the monthly benefit amount before the NRA (see SSA-S 2005, p.18), \(MP3Y\) are the months not claimed in the period prior to 3 years before NRA, and \(M3Y\) are months not claimed in 3 years before NRA. Assuming that the individual continues to receive benefits, her \(MBA_t\) is permanently reduced. The Actuarial Reduction Factor (ARF) underlying this calculation is a permanent reduction of benefits by 5/9 of 1 percent per month for each month in which benefits are received in the three years immediately prior to the NRA. The reduction of benefits is 5/12 of 1 percent for every month before that. Thus, the maximum actuarial reduction will reach 30 percent as the NRA increases to 67 over the next few years (see SSA-S 2005, p.18).

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11 In this paper, we are not considering spousal benefits and joint decision making in the household. The complexities introduced by those considerations are out of the scope of this analysis. See Gustman and Steinmeier (1991), Coile, Diamond, Gruber, and Jousten (2002), and Votruba (2003) for a discussion. By ignoring spousal benefits we are not taking into account the fact that approximately 5.96% of the individuals who receive some type of Old Age, Survivors, or Disability Insurance (OASDI) benefits receive them as spouses of entitled retirees. This percentage comes from the Public-Use Microdata File provided by the Social Security Administration and refers to a 1% random sample of all beneficiaries as of December of 2001.

12 Given a NRA of 66, which will be the prevailing one for the cohort born between 1943 and 1954, the Actuarial Reduction Factor is a number between 0.75 and 1 depending on when the individual claims benefits, and how many months he or she earns above the Earnings Test after claiming benefits.

13 Six percent of the 153 million workers with Social Security taxable earnings in 2002 had earnings at or above the maximum amount.

14 The reductions in benefits for early claimers are designed to be approximately actuarially fair for the average
Actuarial Reduction Factor

One less-emphasized feature of the process of benefit reduction due to early retirement is the possibility to reduce the penalty even after initiating the receipt of benefits. The specifics of this adjustment to the Actuarial Reduction Factor are documented in the Social Security Handbook (SSA-H, §724. Basic reduction formulas, §728. Adjustment of reduction factor at FRA) and in the internal operating manual used by Social Security field employees when processing claims for Social Security benefits (SSA-M, RS00615. Computation of Monthly Benefits Amounts) but may not be well-understood by the retirees. To illustrate this feature of the system, suppose the NRA is 66 years, and an individual claims benefits at age 62 and \( n \) months, where \( n << 48 \), receives checks for \( x \) months where \((n + x << 48)\), and suspends receiving checks after that until she turns 66 (after which she retires for good). In this case she receives \( x \) checks of

\[
MBA_t = \begin{cases} 
(0.75 + 0.05 \times \frac{1}{12} \times n) \times PIA & \text{if claimed more than 3 years before NRA}, \\
(0.80 + 0.20 \times \frac{1}{36} \times n) \times PIA & \text{if claimed within the 3 years before NRA}.
\end{cases}
\]

After turning 66, her \( MBA \) will be permanently increased to

\[
MBA_t = [0.75 + (0.20 \times \frac{1}{36} \times n) + (0.20 \times \frac{1}{36} \times (36 - n - x)) + 0.05] \times PIA. \tag{13}
\]

It is important to note that the adjustment of the ARF is automatic and becomes effective only after reaching the NRA.

Earnings Test

The Earnings Test limit defines the maximum amount of income from work that a beneficiary who claims benefits before the NRA under OASI may earn while still receiving the “full” \( MBA \). Earnings above the limit are taxed at a rate of 50 percent for beneficiaries between age 62 and the January of the year in which they reach the NRA, and 33 percent from January of that year until the month they reach the NRA (SSA-S 2005, p.19; SSA-S 2005, Table 2.A18). For the latter period, the earnings limit is higher, $31,800, compared with $12,000 for the earlier period as of 2005 (SSA-S 2005, Table 2.A29). Starting in 2000, the Earnings Test was eliminated for individuals over the NRA.

Individuals who continue or reenter employment after claiming Social Security benefits before the NRA, and whose earning power or hours constraints are such that their income from work is around or below the earnings limit, are mailed their full monthly check from Social Security and are locked-in at the reduced benefit rate permanently. Those with earnings above the

The Social Security Administration does not use the term Actuarial Reduction Factor in their publications, but a number of the people we have talked to within the administration do use this terminology. In publications the related concept of “Reduction Factor(s)” (RF) which is simply the number of months in which benefits were received before the NRA is used. The RF maps into a “Fraction” that ranges between 0.75 and 1 (for an ERA of 62 and an NRA of 66). The latter corresponds to what we refer to as ARF. The ARF (“Fraction”) is adjusted upwards at the NRA according to the number of months before the NRA in which benefits were withheld.

Some sources of income do not count under the Earnings Test. For details see SSA-H §1812. Notice that retirement contributions by the employer do not count towards the limit, but additional contributions by the employee even if they are through a payroll deduction are counted. This means that individuals earning above the limit cannot just increase their retirement savings to avoid being subject to the limit. We thank Barbara Lingg and Christine Vance from the Social Security Administration for clarifying this point, which is rarely discussed in any publication.
limit will not receive checks from Social Security for some months and thereby adjust their ARF. Individuals have the option of informing Social Security to suspend the monthly benefit payment at any time if they believe they will be making earnings high enough above the Earnings Test. However, during the first year after claiming benefits, the Social Security Administration performs a monthly test to determine whether the person should receive the monthly check. As a result an early claimer who is not working or earns below the limit in the months after claiming (“grace year”) will receive all monthly benefits even if earnings for that calendar year exceed the Earnings Test limit due to high earnings before claiming. After the first year, the test is typically yearly and it depends on the expected earnings of the individual. Given the scarce documentation of the functioning of the ARF, having earned above the earnings limit, and thus receiving fewer checks, may be a common way for beneficiaries to learn about the possibility of undoing the early retirement penalty.

17A beneficiary may receive a partial monthly benefit at the end of the tax year if there are excess earnings that do not completely offset the monthly benefit amount (see SSA-H, §1806).

18Social Security claim specialists emphasized to us that during the first year after claiming they do what is most advantageous to the claimer, the monthly or the yearly test, if they have enough information. However, they failed to clarify what that means. Some of them said the number of checks individuals receive is maximized, but we were unable to find documentation of such practices. In any case, the internal operating instructions used by Social Security field employees when processing claims for Social Security benefits state that the monthly earnings test only applies for the calendar year when benefits are initiated unless the type of benefit changes (see SSA-M, RS02501.030).

19See Benítez-Silva and Heiland (2006b) for a numeric example of the streams of income resulting from these incentives.
Appendix SPAIN: Social Security Incentives for Early Retirement

7.1 Labor market reforms since the 1970’s

The Spanish labor market has suffered substantial changes in employment protection legislation over the last three decades. The following chronology describes the major legislative changes in the Spanish labor market,

1978: Following the transition to democracy in 1978, Spain introduced labor legislation restricting dismissals + high dismissal costs.20


1984: First reform of the labor market with the objective of reducing dismissal cost. It introduced temporary contracts, very popular since then. As a result of the 1984 reform, the proportion of employees under temporary contracts increased from 10% during the 1980’s to over 30% in the early 1990’s.

The main concern with the liberalization of temporary contracts after 1984 was that it generated segmentation between unstable low-paying jobs and stable high-paying jobs, without appearing to reduce unemployment (Kugler et al. (2002)).

The duality of the labor market is very pronounced since then. In many respects the Spanish labor market was an extreme case within the OECD. Spain not only suffered from one of the highest unemployment rates for many years, but also had one of the highest effective levels of severance payments for permanent workers. Not surprisingly, reducing firing costs has been one of the recurrent recommendations of national and international organisations, although in practice reforms had only limited scope. (OECD, 2005)

This caused the next reform that was passed in 1994.

1994: Second major reform of the labor market with the objective of introducing limitations to the use of temporary contracts (one of the highest fractions in Europe).

1997: Third important reform of the labor market (actualized in 2001). The purpose of this reform was to further reduce the use of temporary contracts by further reducing dismissal cost of certain groups of the population.

The main aim of the agreement, which was quickly passed into law (May 1997 labor legislation), was to foster stable employment and to improve the collective bargaining processes. Regarding the first objective, the new legislation attempted to reduce the large number of workers under fixed-term contracts. The most noted aspect of the reform was the introduction of a new permanent contract, with reduced severance payments. This contract was targeted to two

20This legislation established that firms could dismiss workers for ”personal reasons,” in which case the firm had to prove the worker’s incompetence or absenteeism; and ”economic reasons,” in which case the firm had to prove its need to reduce employment due to technological, organizational, or productive causes. Dismissals justified by ”economic reasons” required advance notice. Workers dismissed for ”personal reasons” could appeal to labor courts. The severance payment awarded depended on whether judges ruled the dismissal as ”fair” or ”unfair.” A dismissal was ruled as ”fair” if the employer was able to prove the worker’s incompetence or absenteeism and ”unfair” otherwise. In case of fair dismissals, firms had to pay 20 days out of the salary per year of seniority, with a maximum of 12 months. In the case of unfair dismissals, firms had to pay 45 days per year of seniority out of the salary, with a maximum of 42 months. Severance payments for ”economic reasons” were the same as for fair dismissals under ”personal reasons.” In practice, this legislation turned out to be very stringent because judges ruled dismissals as unfair in the majority of cases. Moreover, approval for dismissals under ”economic reasons” was often granted only when there was an agreement between employers and workers, which was achieved in most cases by raising severance payments above the legally established amounts. The Spanish government introduced the first reform designed to reduce dismissal costs in 1984. Since an across-the-board reduction of dismissal costs was politically impossible, the reform liberalized the use of temporary contracts. [from Kugler, Herranz, Jimeno (1999)].
groups: the population most exposed to unemployment (i.e. the youth, the long term unemployed, and women and men above age 45), and workers on a temporary contract who converted to an indefinite one during the one-year period following the implementation of the May labor market legislation.

2006: Fourth important labor market reform. Since the previous reforms have failed to reduce the fraction of temporary contract, this reform was passed to reduce it via strong restrictions to contract extensions or replacement in a job post.

7.2 Background on the Spanish Social Security System

7.3 The 1985 Reform and the Current System

Currently, the Spanish Social Security offers two pathways to regular retirement\textsuperscript{21}: early retirement and normal retirement. Early retirement is possible starting at age 60, while the normal retirement age is 65, although some professional groups have lower normal retirement ages (miners, military personnel, policemen and fishermen are the main ones). Collective wage settlements often impose mandatory retirement at age 65, facilitate retirement at 64 with full benefits, or encourage retirement between 60 and 63 through generous severance payments.

Public pensions are provided by the following programs.

- The “General Social Security Scheme” (Régimen General de la Seguridad Social, or RGSS) and the “Special Social Security Schemes for Self-employed” (Régimen Especial de Trabajadores Autónomos or RETA). They cover, respectively, the private sector employees and the self-employed workers and professionals. The RGSS covers also the members of cooperative firms, the employees of most public administrations other than the central governments and all unemployed individuals complying with the minimum number of contributory years when reaching 65.

- The scheme for government employees (Régimen de Clases Pasivas, or RCP) includes public servants employed by the central government and its local branches.

7.4 Rules of the RGSS

This subsection describes the rules governing, since 1985, the old-age and survivors pensions in the RGSS. The changes introduced by the 1997 reform (R97) and the 2002 (A02) amendment will be illustrated as we go along. A summary of the basic technical aspects of the pre- and post-1997 systems can be found in Table 1.

Financing and Eligibility

The RGSS is a pure pay-as-you-go scheme. Contributions are a fixed proportion of covered earnings, defined as total earnings, excluding payments for overtime work, between a floor and a ceiling that vary by broadly defined professional categories. Currently, eleven categories are distinguished, each one with its own ceiling and floor for covered earnings. The current RGSS contribution rate is 28.3 percent, of which 23.6 percent is attributed to the employer and the remaining 4.7 percent to the employee. A tax rate of 14 percent is levied on earnings from overtime work.

Entitlement to an old-age pension requires at least 15 years of contributions. As a general rule, recipiency is conditional on having reached age 65 and is incompatible with income from any kind of employment requiring affiliation to the Social Security system.

\textsuperscript{21}That is to say, in the absence of disability or long term unemployment in late age.
**Benefit computation**

When eligibility conditions are met, a retiring worker receives an initial monthly pension $P_t$ equal to

$$P_t = \alpha_n \text{BR}_t,$$

where the benefit base (base reguladora) $\text{BR}_t$ is a weighted average of covered monthly earnings over a reference period that consisted in the last 8 years before retirement until the 1997 reform. Therefore, the $\text{BR}_t$ using 8 years as the number of contributive years is calculated as:

$$\text{BR}_t = \frac{1}{112} \left( \sum_{j=1}^{24} W_{t-j} + \sum_{j=25}^{96} W_{t-j} \frac{I_{t-25}}{I_{t-j}} \right),$$

where $W_{t-j}$ and $I_{t-j}$ are earnings and the consumer price index in the $j$-th month before retirement. Pensions are paid in fourteen annual installments, hence the division by 112 in the previous formula.

The replacement rate $\alpha_n$ depends on the age of the retirees and on the number of years of contribution. When age is below 60, $\alpha_n = 0$ for all $n$. For age equal or larger than 65, $\alpha_n$ is equal to

$$\alpha_n = \begin{cases} 
0, & \text{if } n < 15, \\
.6 + .02(n - 15), & \text{if } 15 \leq n < 35, \\
1, & \text{if } 35 \leq n.
\end{cases}$$

In the case of early retirement, i.e. for ages between 60 and 65, $\alpha_n$ is determined by the previous formula multiplied by a penalization factor. The latter is equal to .60 at 60, and increases by .08 each year, until reaching the value of 1.0 at age 65.

Beginning in 1997, the number of reference years used for computing $\text{BR}_t$ has been increased by one every year until 2003, to reach a total of 15 years. The formula for computing $\alpha_n$ has been changed to the following

$$\alpha_n = \begin{cases} 
0, & \text{if } n < 15, \\
.5 + .03(n - 15), & \text{if } 15 \leq n < 25, \\
.8 + .02(n - 25), & \text{if } 25 \leq n < 35, \\
1, & \text{if } 35 \leq n.
\end{cases}$$

The penalization factors have, basically, remained the same, exception made for workers with 40 or more years of contributions (details in the next subsection).

The A02 amendment allows for the possibility of $\alpha_n$ being greater that one when people are above 65 years of age, that is

$$\alpha_n = \begin{cases} 
1 + .02(a - 65), & \text{if } 65 \leq a \text{ and } n \geq 35,
\end{cases}$$

Outstanding pensions are fully indexed to price inflation, as measured by the consumer price index. Until 1986, pensions were also indexed to real wage growth.

**Early retirement**

The normal retirement age is 65 but early retirement at age 60 is permitted under fairly common circumstances. The replacement rate for early retirees is reduced by 8 percentage points for each year under age 65. Starting from 1997, workers who retire after the age of 60 with 40 or more contributive years are charged a penalty of only 7 percent for each year under age 65. The 2002
amendment has modified further the rules determining the replacement rate. It now reads as follows

\[
\alpha_n = \begin{cases} 
0, & \text{if } a < 61, \\
1 - \kappa(a - 60), & \text{if } 61 \leq a < 65, \\
1, & \text{if } 65 \leq a.
\end{cases}
\]

where,

\[
\kappa = \begin{cases} 
0.08, & \text{if } n = 30, \\
0.075, & \text{if } 31 \leq n \leq 34, \\
0.07, & \text{if } 35 \leq n \leq 37, \\
0.065, & \text{if } 38 \leq n \leq 39, \\
0.06, & \text{if } 40 \leq n.
\end{cases}
\]

Unless a collective labor agreement prescribes mandatory retirement, individuals may continue working after age 65. Before 2002 there were no incentives to work past age 65. As mentioned, the 2002 legislation now allows for

\[
\alpha_n = \begin{cases} 
1 + .02(a - 65), & \text{if } 65 \leq a \text{ and } n \geq 35,
\end{cases}
\]

and eliminates social security contributions for workers meeting the eligibility criteria for full normal retirement \((a \geq 65 \text{ and } n \geq 35)\) and who continue working.

**Maximum and minimum pension**

Pensions are subject to a ceiling, legislated annually and roughly equal to the ceiling on covered earnings. The 2008 ceiling corresponds to about 4.5 times the minimum wage \((salario mínimo interprofesional, \text{ or SMI})\) and about 1.7 times the average monthly earnings in the manufacturing and service sectors. If the initial old-age pension, computed as above, is below a minimum, then the minimum pension is paid given some income restrictions are met. The latter is also legislated annually. Other things being equal, minimum pensions are higher for those who are older than 65 or have a dependent spouse.

In the last decade, minimum pensions grew at about the same rate as nominal wages, whereas maximum pensions grew at the rate of inflation. The ratio between the minimum old-age pension and the minimum wage has been increasing steadily from the late 1970s (it was 75 percent in 1975) until reaching almost 100 percent in the early 1990s, and above 110 percent by 2005. The percentage of RGSS retirees receiving a minimum pension has been declining steadily, from over 75 percent in the late 1970s to 20 percent in 255.

**Family considerations**

A pensioner receives a fixed annual allowance for each dependent child that is younger than 18 or disabled. In 2008, this allowance was equal to or \(2380.28 \text{ €}\) for each child under 18, which corresponds to 28 percent of the annual minimum wage, and to \(2817 \text{ €}\), or 34 percent of the annualized minimum wage, for each disabled child.

Survivors (spouse, children, other relatives) may receive a fraction of the benefit base of the deceased if the latter was a pensioner or died before retirement after contributing for at least 500 days in the last 5 years. The surviving spouse gets 45 percent of the benefit base of the deceased (46 percent after the 2002 amendment, fraction that will be increased further in the forthcoming years). Such pension is compatible with labor income and any other old-age or disability pension, but is lost if the spouse marries anew. Each of the surviving children gets
20 percent of the benefit base until the age of 18 (amount raised to 23 per cent in 1997). An orphan who is the sole beneficiary may receive up to 65 percent of the benefit base. If there are several surviving children, the sum of the pensions to the surviving spouse (if any) and the children cannot exceed 100 percent of the benefit base.

A Spanish peculiarity is the “pension in favor of family members”. This pension entitles other surviving relatives (e.g. parents, grandparents, siblings, nephews, etc.) to 20 percent of the benefit base of the principal if they satisfy certain eligibility conditions (older than 45, do not have a spouse, do not have other means of subsistence, have been living with and depending economically upon the deceased for the last two years). To this pension, one may add the 45 percent survivors pension if there is no surviving spouse or eligible surviving children.

7.5 Unemployment Benefits

The Spanish Social Protection system through the Instituto Nacional de Empleo (INEM) provides contributory and non-contributory coverage against unemployment spells.

7.5.1 Contributory Unemployment Benefits

There exists a program protecting employees against a non-voluntary unemployment spell. Duration of benefits ranges from 120 to 720 days, increasing at the rate of 120 days per year of contribution within the previous six years. The amount of benefits is a function of the benefit base, which is the average of the contributive bases during the 180 days preceding the unemployment spell. The minimum benefit amount in 2008 was 413,52 € (80 percent of the IPREM or the minimum reference for assistance income). The maximum benefit amount is a function of the number of dependent children. Without children it equals 1050,33 €. With 2+ children it equals 1356,86 €. Unemployment benefits are subject to both SS contributions and income taxes.

7.5.2 Subsidy for 52+ workers

There exists a special unemployment scheme for those workers 52+ (UB52+) who:

- are eligible for a retirement pension, except for their age.
- have an income below 75 percent of the monthly minimum wage.

The benefit amounts in 2008 was 413,52 € or 80 percent of the IPREM. It can be collected until the person reaches a retirement age, either early or normal. During this time the individual collects UB52+ the system assigns a fictitious contribution that amounts 125 of the minimum wage (600 € in 2008).
## Table 1: Pension provisions, institutions and systems

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Provisions affecting all individuals</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Basic ingredients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1. The benefit base formula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Contribution period</td>
<td>8 years</td>
<td>15</td>
</tr>
<tr>
<td>– Fraction actualized</td>
<td>6 years</td>
<td>13</td>
</tr>
<tr>
<td>A2. Fiscal system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Income tax</td>
<td>[progressive]</td>
<td>id.</td>
</tr>
<tr>
<td>– Labor tax</td>
<td>linear (regime and group specific)</td>
<td>id.</td>
</tr>
<tr>
<td>B. Replacement rates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Function of contributive years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0, if ( n &lt; 15 ), ( .6 + .02(n - 15) ), if ( 15 \leq n &lt; 35 ), ( 1 ), if ( 35 \leq n ).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Function of age</td>
<td>exception for ( n \geq 40 ):</td>
<td></td>
</tr>
<tr>
<td>0, if ( a &lt; 60 ), ( .6 + .8(a - 60) ), if ( 60 \leq a &lt; 65 ), ( 1 ), if ( 65 \leq a ).</td>
<td></td>
<td></td>
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<tr>
<td>C. Income tax exemptions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Maximum pension exempted</td>
<td>( \propto ) Minimum wages</td>
<td>id.</td>
</tr>
<tr>
<td>- Income tax exempted</td>
<td>( \propto ) Minimum wages</td>
<td>id.</td>
</tr>
<tr>
<td>D. Min/Max contributions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum level of contribution</td>
<td>(specific for 12 group)</td>
<td>id.</td>
</tr>
<tr>
<td>- Maximum level of contribution</td>
<td>(specific for 12 group)</td>
<td>id.</td>
</tr>
<tr>
<td>E. Min. and Max. pensions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Minimum pension</td>
<td>( \propto ) Minimum wages and family specific</td>
<td>id.</td>
</tr>
<tr>
<td>- Maximum pension</td>
<td>4.3 minimum wage (in 1995)</td>
<td>id.</td>
</tr>
<tr>
<td>F. Age bonuses</td>
<td>YES (occupation specific)</td>
<td>id.</td>
</tr>
<tr>
<td>G. Survivor benefits</td>
<td>0.45 ( \times ) (benefit base)</td>
<td>id.</td>
</tr>
<tr>
<td>H. Dependant benefits</td>
<td>18, 22 (means tested)</td>
<td>18, 23 (means tested)</td>
</tr>
<tr>
<td><strong>Eligibility</strong></td>
<td>2 years contrib. last 10 years</td>
<td>2 out of last 15 years</td>
</tr>
<tr>
<td><strong>Pension computation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( b_t = \max{\min{b_n, e, BR(BC, I)}, b_0} ), ( b_0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>where ( b_n ) is the pension in A+B and ( b_0 ) and ( b_0 ) are respectively the maximum and minimum pension.</td>
<td></td>
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</tbody>
</table>

### 2002 Amendment

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>- Scheme for early retirement</td>
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</table>
| \( \alpha_n = \begin{cases} 
0, & \text{if } a < 61, \\
1 - \kappa(a - 60), & \text{if } 61 \leq a < 65, \\
1, & \text{if } 65 \leq a.
\end{cases} \) | \( 0.08 \), if \( n = 30 \) |
| | \( 0.075 \), if \( 31 \leq n \leq 34 \) |
| | \( 0.07 \), if \( 35 \leq n \leq 37 \) |
| | \( 0.065 \), if \( 38 \leq n \leq 39 \) |
| | \( 0.06 \), if \( 40 \leq n \). |
| - Premium for late retirement | | |
| \( \alpha_n = 1 + 0.02(a - 65) )if \ n \geq 30 \) | | |
| - Social Security contributions: | No contributions for workers 65+. provided \( n \geq 35 \) | | |
| - Survivor benefits | | |
| | 0.46 \( \times \) (benefit base) | | |
Table 2: Doing II: US Social Security Claiming facts

<table>
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<tr>
<th></th>
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<tr>
<td>Age 62</td>
<td>0.5886</td>
<td>0.6008</td>
<td>0.5833</td>
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<td>Age 63</td>
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<td>0.0746</td>
<td>0.0801</td>
<td>0.0671</td>
<td>0.0779</td>
<td>0.0777</td>
<td>0.0782</td>
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<td>0.0830</td>
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<td>Age 64</td>
<td>0.1212</td>
<td>0.1080</td>
<td>0.1077</td>
<td>0.1045</td>
<td>0.1344</td>
<td>0.1484</td>
<td>0.1273</td>
<td>0.1094</td>
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<td>Age 65</td>
<td>0.1566</td>
<td>0.1568</td>
<td>0.1557</td>
<td>0.1959</td>
<td>0.1785</td>
<td>0.1724</td>
<td>0.1784</td>
<td>0.1862</td>
<td>0.1974</td>
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<tr>
<td>Age 66</td>
<td>0.0182</td>
<td>0.0199</td>
<td>0.0210</td>
<td>0.0392</td>
<td>0.0130</td>
<td>0.0096</td>
<td>0.0105</td>
<td>0.0122</td>
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<tr>
<td>Age 67-69</td>
<td>0.0230</td>
<td>0.0256</td>
<td>0.0286</td>
<td>0.0550</td>
<td>0.0199</td>
<td>0.0152</td>
<td>0.0160</td>
<td>0.0177</td>
<td>0.0187</td>
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<tr>
<td>Age 70+</td>
<td>0.0128</td>
<td>0.0140</td>
<td>0.0232</td>
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<td>0.0161</td>
<td>0.0193</td>
<td>0.0178</td>
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# Claimants
1,444.5 1,396.1 1,441.3 1,578.9 1,547.0 1,595.5 1,593.3 1,680.3 1,793.5

Average benefits

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<tr>
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<tr>
<td>Age 62</td>
<td>788.58</td>
<td>785.31</td>
<td>815.35</td>
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<td>1,002.8</td>
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<td>986.9</td>
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<td>981.51</td>
<td>997.16</td>
<td>1,001.7</td>
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<td>1,119.7</td>
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<td>Age 65</td>
<td>1,083.9</td>
<td>1,087.8</td>
<td>1,088.0</td>
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<td>1,176.1</td>
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<td>1,270.9</td>
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<td>Age 66</td>
<td>1,022.4</td>
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<td>1,030.4</td>
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<td>Age 67</td>
<td>1,027.8</td>
<td>1,071.4</td>
<td>1,050.2</td>
<td>1,285.7</td>
<td>911.44</td>
<td>873.48</td>
<td>877.89</td>
<td>933.59</td>
<td>1,010.4</td>
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Table 3: Spanish Social Security Claiming Behavior, 1991-2004

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<tr>
<th>Age/Year</th>
<th>1991</th>
<th>1995</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
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<tbody>
<tr>
<td>60</td>
<td>37.88</td>
<td>38.10</td>
<td>31.08</td>
<td>31.10</td>
<td>29.09</td>
<td>28.19</td>
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<td>61</td>
<td>7.02</td>
<td>8.67</td>
<td>6.57</td>
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<td>8.70</td>
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<tr>
<td>62</td>
<td>6.54</td>
<td>9.18</td>
<td>5.74</td>
<td>7.72</td>
<td>8.09</td>
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<td>63</td>
<td>5.67</td>
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<tr>
<td>64</td>
<td>6.50</td>
<td>8.41</td>
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<td>8.07</td>
<td>9.25</td>
<td>11.19</td>
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<tr>
<td>65</td>
<td>31.51</td>
<td>24.72</td>
<td>35.99</td>
<td>31.30</td>
<td>33.80</td>
<td>30.60</td>
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<tr>
<td>66+</td>
<td>4.01</td>
<td>2.71</td>
<td>4.24</td>
<td>5.85</td>
<td>5.24</td>
<td>4.97</td>
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</table>

Average initial benefit. 2007 euros.

<table>
<thead>
<tr>
<th>Age/Year</th>
<th>1991</th>
<th>1995</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>480.9</td>
<td>633.3</td>
<td>919.2</td>
<td>1099.6</td>
<td>1244.8</td>
<td>1237.7</td>
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<tr>
<td>61</td>
<td>567.3</td>
<td>862.5</td>
<td>1035.0</td>
<td>1080.6</td>
<td>1206.6</td>
<td>1156.9</td>
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<tr>
<td>62</td>
<td>710.0</td>
<td>960.8</td>
<td>1091.3</td>
<td>1201.3</td>
<td>1256.0</td>
<td>1158.8</td>
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<tr>
<td>63</td>
<td>882.7</td>
<td>1049.5</td>
<td>1242.6</td>
<td>1289.6</td>
<td>1341.3</td>
<td>1204.5</td>
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<tr>
<td>64</td>
<td>1063.8</td>
<td>1208.3</td>
<td>1339.4</td>
<td>1364.4</td>
<td>1457.5</td>
<td>1377.6</td>
</tr>
<tr>
<td>65</td>
<td>949.5</td>
<td>1052.2</td>
<td>1105.2</td>
<td>1110.3</td>
<td>1161.1</td>
<td>1132.5</td>
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<tr>
<td>66+</td>
<td>813.0</td>
<td>817.4</td>
<td>1020.2</td>
<td>1035.0</td>
<td>1198.7</td>
<td>1157.9</td>
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</table>

Number do not sum up to 100%, because a small fraction (around 0.5%) that retire before age 60.
Table 4: Sample distribution by tenure, age and skill level. Spain. 2007.

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<tr>
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<th>8-11</th>
<th>12-15</th>
<th>16-19</th>
<th>20-23</th>
<th>24-27</th>
<th>28+</th>
<th>-1</th>
<th>1-2</th>
<th>2+</th>
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Clerical and unskilled workers

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<td>0.073</td>
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</tbody>
</table>

Table 5: US 10,000 Simulations of the Dynamic Retirement Model

<table>
<thead>
<tr>
<th>Ages</th>
<th>Survivors</th>
<th>Full-Time$^a$</th>
<th>Part-Time$^a$</th>
<th>No Work$^a$</th>
<th>Claimers$^b$</th>
<th>Benefits($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: Earnings Test as a Tax</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 60</td>
<td>8,234</td>
<td>5,749 (69.8%)</td>
<td>163 (5.7%)</td>
<td>2,322 (28.8%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 61</td>
<td>8,078</td>
<td>5,635 (69.7%)</td>
<td>213 (2.6%)</td>
<td>2,230 (27.6%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 62</td>
<td>7,951</td>
<td>4,714 (59.2%)</td>
<td>2 (0.02%)</td>
<td>3,235 (40.6%)</td>
<td>2,672 (34.9%)</td>
<td>1,042</td>
</tr>
<tr>
<td>Age 63</td>
<td>7,762</td>
<td>2,013 (25.9%)</td>
<td>856 (11.0%)</td>
<td>4,893 (63.0%)</td>
<td>1,331 (17.4%)</td>
<td>1,151</td>
</tr>
<tr>
<td>Age 64</td>
<td>7,586</td>
<td>495 (6.5%)</td>
<td>2,008 (26.4%)</td>
<td>5,083 (67.0%)</td>
<td>1,048 (13.7%)</td>
<td>1,272</td>
</tr>
<tr>
<td>Age 65</td>
<td>7,420</td>
<td>113 (1.5%)</td>
<td>2,731 (36.8%)</td>
<td>4,576 (61.6%)</td>
<td>1,362 (17.8%)</td>
<td>1,391</td>
</tr>
<tr>
<td>Age 66</td>
<td>7,239</td>
<td>414 (5.7%)</td>
<td>3,484 (48.1%)</td>
<td>3,341 (46.1%)</td>
<td>847 (11.0%)</td>
<td>1,500</td>
</tr>
<tr>
<td>Model 2: Earnings Test with ARF Adjustments</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 60</td>
<td>8,234</td>
<td>5,749 (69.8%)</td>
<td>154 (1.8%)</td>
<td>2,331 (28.3%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 61</td>
<td>8,078</td>
<td>5,636 (69.7%)</td>
<td>214 (2.6%)</td>
<td>2,228 (27.5%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 62</td>
<td>7,951</td>
<td>4,058 (51.0%)</td>
<td>0</td>
<td>3,893 (49.0%)</td>
<td>3,741 (48.3%)</td>
<td>981</td>
</tr>
<tr>
<td>Age 63</td>
<td>7,762</td>
<td>1,057 (21.3%)</td>
<td>1,387 (17.8%)</td>
<td>4,718 (60.7%)</td>
<td>1,073 (13.8%)</td>
<td>1,155</td>
</tr>
<tr>
<td>Age 64</td>
<td>7,586</td>
<td>343 (5.7%)</td>
<td>2,413 (31.8%)</td>
<td>4,739 (62.5%)</td>
<td>815 (10.5%)</td>
<td>1,277</td>
</tr>
<tr>
<td>Age 65</td>
<td>7,420</td>
<td>175 (2.4%)</td>
<td>3,139 (42.3%)</td>
<td>4,106 (55.3%)</td>
<td>1,808 (23.3%)</td>
<td>1,390</td>
</tr>
<tr>
<td>Age 66</td>
<td>7,239</td>
<td>553 (7.6%)</td>
<td>4,179 (57.7%)</td>
<td>2,507 (34.6%)</td>
<td>306 (4.1%)</td>
<td>1,480</td>
</tr>
<tr>
<td>Model 3: ET with ARF Adjustments and Unemployment Uncertainty</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 60</td>
<td>8,234</td>
<td>5,574 (67.6%)</td>
<td>133 (1.61%)</td>
<td>2,527 (30.6%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 61</td>
<td>8,078</td>
<td>5,458 (67.56%)</td>
<td>212 (2.62%)</td>
<td>2,408 (29.8%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 62</td>
<td>7,951</td>
<td>3,437 (43.22%)</td>
<td>1 (0.00%)</td>
<td>4,513 (56.8%)</td>
<td>4,495 (57.5%)</td>
<td>1,019</td>
</tr>
<tr>
<td>Age 63</td>
<td>7,762</td>
<td>1,256 (16.18%)</td>
<td>1,969 (25.4%)</td>
<td>4,537 (58.4%)</td>
<td>1,303 (16.7%)</td>
<td>1,042</td>
</tr>
<tr>
<td>Age 64</td>
<td>7,586</td>
<td>300 (3.95%)</td>
<td>3,156 (41.6%)</td>
<td>4,130 (54.4%)</td>
<td>740 (9.47%)</td>
<td>1,084</td>
</tr>
<tr>
<td>Age 65</td>
<td>7,420</td>
<td>723 (1.65%)</td>
<td>3,814 (51.4%)</td>
<td>3,483 (46.9%)</td>
<td>1,113 (14.25%)</td>
<td>1,171</td>
</tr>
<tr>
<td>Age 66</td>
<td>7,239</td>
<td>283 (3.9%)</td>
<td>4,447 (61.4%)</td>
<td>2,509 (34.6%)</td>
<td>160 (2.05%)</td>
<td>1,184</td>
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</table>
Table 6: Spain 10,000 Simulations of the Dynamic Retirement Model

<table>
<thead>
<tr>
<th>Ages</th>
<th>Survivors</th>
<th>Full-Time$^a$</th>
<th>Part-Time$^a$</th>
<th>No Work$^a$</th>
<th>Claimers$^b$</th>
<th>Benefits in €</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age 40</td>
<td>Age 50</td>
<td>Age 60</td>
<td>Age 61</td>
<td>Age 62</td>
</tr>
<tr>
<td>Model 1: Benchmark: No unemployment uncertainty or Firing Costs</td>
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<tr>
<td>Age 40</td>
<td>9,816</td>
<td>8,400 (85.57%)</td>
<td>0 (0%)</td>
<td>1,416 (14.43%)</td>
<td>—</td>
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</tr>
<tr>
<td>Age 50</td>
<td>9,613</td>
<td>6,966 (72.46%)</td>
<td>0 (0%)</td>
<td>2,647 (27.54%)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Age 60</td>
<td>9,161</td>
<td>5,627 (61.42%)</td>
<td>0 (0%)</td>
<td>3,534 (39.58%)</td>
<td>1,229 (13.85%)</td>
<td>774</td>
</tr>
<tr>
<td>Age 61</td>
<td>9,091</td>
<td>3,590 (39.5%)</td>
<td>0 (0%)</td>
<td>5,502 (61.5%)</td>
<td>302 (3.4%)</td>
<td>932</td>
</tr>
<tr>
<td>Age 62</td>
<td>9,003</td>
<td>1,670 (18.5%)</td>
<td>0 (0%)</td>
<td>7,333 (82.5%)</td>
<td>259 (2.9%)</td>
<td>1,045</td>
</tr>
<tr>
<td>Age 63</td>
<td>8,935</td>
<td>850 (9.51%)</td>
<td>0 (0%)</td>
<td>8,085 (90.49%)</td>
<td>218 (2.4%)</td>
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</tr>
<tr>
<td>Age 64</td>
<td>8,852</td>
<td>269 (3.03%)</td>
<td>0 (0%)</td>
<td>8,583 (96.97%)</td>
<td>457 (5.15%)</td>
<td>1,287</td>
</tr>
<tr>
<td>Age 65</td>
<td>8,758</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>8,758 (100%)</td>
<td>6,406 (72.2%)</td>
<td>1,417</td>
</tr>
<tr>
<td>Model 2: Includes Unemployment Uncertainty</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 50</td>
<td>9,612</td>
<td>6,639 (69.06%)</td>
<td>0 (0%)</td>
<td>2,973 (30.94%)</td>
<td>—</td>
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</tr>
<tr>
<td>Age 60</td>
<td>9,160</td>
<td>5,314 (58.01%)</td>
<td>0 (0%)</td>
<td>3,846 (41.99%)</td>
<td>1,114 (12.6%)</td>
<td>765</td>
</tr>
<tr>
<td>Age 61</td>
<td>9,091</td>
<td>3,553 (39.08%)</td>
<td>0 (0%)</td>
<td>5,538 (60.92%)</td>
<td>389 (4.38%)</td>
<td>917</td>
</tr>
<tr>
<td>Age 62</td>
<td>9,003</td>
<td>1,712 (19.01%)</td>
<td>0 (0%)</td>
<td>7,291 (80.99%)</td>
<td>287 (3.23%)</td>
<td>1,010</td>
</tr>
<tr>
<td>Age 63</td>
<td>8,935</td>
<td>868 (9.71%)</td>
<td>0 (0%)</td>
<td>8,067 (90.29%)</td>
<td>205 (2.3%)</td>
<td>1,138</td>
</tr>
<tr>
<td>Age 64</td>
<td>8,852</td>
<td>286 (3.23%)</td>
<td>0 (0%)</td>
<td>8,566 (96.77%)</td>
<td>560 (6.3%)</td>
<td>1,292</td>
</tr>
<tr>
<td>Age 65</td>
<td>8,758</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>8,758 (100%)</td>
<td>6,311 (71.2%)</td>
<td>1,417</td>
</tr>
<tr>
<td>Model 3: Includes Unemployment Uncertainty and Firing Costs</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Age 50</td>
<td>9,580</td>
<td>6,780 (70.77%)</td>
<td>618 (6.45%)</td>
<td>2,182 (22.77%)</td>
<td>—</td>
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</tr>
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<td>9,125</td>
<td>3,476 (38.1%)</td>
<td>0 (0%)</td>
<td>5,649 (61.9%)</td>
<td>4,865 (53.9%)</td>
<td>593</td>
</tr>
<tr>
<td>Age 61</td>
<td>9,060</td>
<td>2,807 (30.98%)</td>
<td>6 (0.06%)</td>
<td>6,247 (68.95%)</td>
<td>687 (7.6%)</td>
<td>781</td>
</tr>
<tr>
<td>Age 62</td>
<td>8,974</td>
<td>2,282 (25.43%)</td>
<td>3 (0.03%)</td>
<td>6,689 (74.53%)</td>
<td>641 (7.1%)</td>
<td>812</td>
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<tr>
<td>Age 63</td>
<td>8,882</td>
<td>1,452 (16.34%)</td>
<td>3 (0.03%)</td>
<td>7,427 (83.62%)</td>
<td>598 (6.6%)</td>
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</tr>
<tr>
<td>Age 64</td>
<td>8,801</td>
<td>133 (1.51%)</td>
<td>2 (0.2%)</td>
<td>8,666 (98.46%)</td>
<td>1,650 (18.28%)</td>
<td>970</td>
</tr>
<tr>
<td>Age 65</td>
<td>8,710</td>
<td>0 (0%)</td>
<td>1 (0.02%)</td>
<td>8,709 (99.98%)</td>
<td>581 (6.43%)</td>
<td>1,036</td>
</tr>
</tbody>
</table>