Estimation of a Structural Model for Retirement in Uruguay*

Alvaro Forteza †  Graciela Sanroman ‡
February 2012

Abstract

In this paper we estimate a structural model for retirement behavior using data of labor history of public employees in Uruguay. We use a modified version of the model proposed by Jiménez-Martín and Sánchez-Martín (2007) adjusted to the Uruguayan case. The estimated coefficient of relative risk aversion is around 2, indicating that agents are moderately risk-averse. The probability of retirement is greater for individuals who have lower propensity to contribute and increases for women and older people. Finally, simulations show a very low sensitivity of the age of retirement to moderate policy changes.

Keywords: Social Security, Retirement, Structural model, ML estimation

JEL: H55, J14, J26, D91

*This work is part of project FCE2007_293, financed by ANII. Ianina Rossi decisively collaborated with this paper. Nevertheless, the authors take full responsibility for its contents.
†Departamento de Economía, Facultad de Ciencias Sociales Universidad de la República. alvarof@decon.edu.uy
‡Departamento de Economía, Facultad de Ciencias Sociales Universidad de la República. gsanroman@decon.edu.uy
1 Introduction

The decline in the age of retirement of men that has taken place in several OECD countries in the last decades attracted considerable attention among policymakers and scholars. Basically two explanations can be found in the literature, namely the increase in wealth that induces individuals to consume more leisure (Burtless and Quinn, 2000) and the implicit incentives in social security (Gruber and Wise, 1999, 2004). This trend, combined with population aging represents a significant challenge for the sustainability of many pension systems. There has not been a similar decline in the retirement age of Uruguayan workers (Alvarez et. al. 2010), but low fertility compounded by emigration has pushed the country aging process further than in most other Latin American countries.

Recently available microdata from the social security administration has allowed the analysis of the impact of social security reforms on individual behavior and the macroeconomy (Forteza et al, 2009; Bucheli et al, 2010, Alvarez et al, 2009). These studies are based on the estimation of reduced form models that are not immune to the Lucas critique: the policy response parameters being estimated are not necessarily invariable to policy changes.

In this paper, we estimate a structural retirement and savings decision model, similar to the life cycle with uncertain longevity and credit rationing model recently estimated for the Spanish economy by Jiménez-Martín and Sánchez-Martín (2007). This relatively simple model adequately reproduces the retirement patterns of Spanish workers. Jiménez-Martín and Sánchez-Martín used for their study administrative records of the Spanish social security. This is very similar to the information we have for the Uruguayan main social security program. Hence, the methodology is applicable to this case. We estimate the model using maximum likelihood.

We use the model to estimate the structural parameters that characterize individuals preferences. As such, they are expected to remain invariant when social security norms change. Hence the model is useful to assess the impact
of policy changes. We present results in several reform scenarios.

This paper is organized as follows. In section 2 we briefly describe the main social security program of Uruguay, administered by the Banco de Previsión Social (BPS). In section 3 we explain the theoretical model and in section 4 we discuss the strategy for the empirical identification of the model and the estimation method. We describe the database in section 5. In section 6, we present the estimation results and in section 7 the simulations. Section 8 concludes.

2 The BPS old-age program

Since the late seventies, two main norms regulate the BPS pension program: the so called Acto Institutional 9 (Institutional Act 9), passed in 1979, and law 16.713, passed in September 1995. It was a pay-as-you-go-defined-benefit (PAYG-DB) program under the Acto Institucional 9, and a mixed program -with a PAYG-DB and a savings accounts pillars- under law 16.713.

Among other things, the 1995 reform modified pension eligibility conditions. Before the reform, individuals were required to have contributed no less than 30 years and be 55 and 60 years old, women and men, respectively, to access and ordinary old-age pension. Law 16.713 tightened some of these conditions: 35 years of service and 60 years of age, both sexes, were required to access an ordinary pension. There was a transition, so that minimum age of retirement for women was gradually adjusted: 56 until 1997, 57 between 1998 and 1999, 58 in 2000 and 2001, 59 in 2002 and 60 from 2003 on. In 2008 a new law reduced the required years of service back to 30.

In the PAYG pillar, the initial benefit is computed multiplying the replacement rate (RR) and the average contribution earnings (ACE). In the Acto 9, the ACE is computed as the average indexed monthly labor earnings in the last three years before retirement. Law 16.713 extended the period to the last ten or the "best" twenty years - i.e. the twenty years with high-
est indexed earnings- before retirement (with an upper bound equal to 1.05 times the average indexed monthly earnings in the "best" twenty years). The index used is the average wage index.

The replacement rates range from 60 to 80 percent in the Acto 9 norms, depending on years of service and retirement age. The maximum is obtained with 40 years of contribution and 70 of age. Law 16.713 widened the range: 50 to 82.5 percent. More recently, in 2008, law 18.395 widened the range even further: 45 to 82.5 percent, also depending on years of service and age at retirement.

There is a minimum and a maximum pension. With Acto 9 norms, the minimum pension was 0.85 times the national minimum salary and the maximum pension was 5 national minimum salaries (or 15 national minimum salaries if the individual had contributed for two or more different jobs). Law 16.713 also sets minimum and maximum pensions in the PAYG-DB pillar. The minimum is 550 and the maximum is 4125 Uruguayan 1995 pesos (indexed to the average wage index). Unlike Acto 9, law 16.713 sets a ceiling on insured wages -and hence on contributions-, with the maximum pension equal to the insured wage ceiling times the maximum replacement rate.

3 Retirement model

We use the structural retirement model proposed by Jiménez-Martín and Sánchez-Martín (2007). It is a stylized life-cycle model suited to the analysis of consumption/savings and retirement decisions.

This model has some advantages over some other models used to study retirement. First, the model has a closed solution. Second, the solution can be used in an econometric model to estimate agents preference parameters.

The strength of this approach (compared to reduced form models) is that it allows the estimation of preference parameters that are not expected to change when policy changes and hence are well suited to simulate the impact
of policy changes on individuals behavior.

The model proposed by Jiménez-Martín and Sánchez-Martín (2007) is an extension of the standard model of Modigliani and Brumberg (1980). It is a model of retirement with uncertain longevity and credit rationing (agents cannot borrow on the future flow of pensions). Agents are assumed to be selfish (or non altruistic) in the sense that no utility is attached to bequests or to the utility of their heirs (Yaari, 1965 and Leung, 1994, 2000). The analysis of retirement decision is similar to the analysis by Crawford and Lilien (1981) and Fabel (1994).

This model presents two advantages relative to other models. First, it solves the computational feasibility problem usually present in standard dynamic programming models. Second, the agents program can be solved in any moment in the life cycle. This is an important advantage in those cases (like ours) in which there is no information about the accumulation of assets.

The model is in continuous time. We assume that the utility function is additively separable both between consumption and leisure and through time. The life-time utility is:

\[
U(c, l, T) = \int_{t_0}^{T} e^{-\delta(t-t_0)} u (c(t), l(t)) \, dt
\]

\[
\nu (c(t), l(t)) = u (c(t)) + v(l(t))
\]

Where:
- \( t = \) time (age)
- \( T \in [t_0, T] \) life duration
- \( c(t) : [t_0, T] \rightarrow R^+ \) consumption in \( t \)
- \( l(t) : [t_0, T] \rightarrow [0, 1] \) leisure in \( t \)
- \( \delta \) subjective discount rate
- \( u() \) and \( v() \) are the utility functions over consumption and leisure respectively and satisfy the usual properties.

The intertemporal problem can thus be written as,
\[
V(c, l) = \max_{c(t), a(t), \tau} E[U(c, l)] \\
= \max_{c(t), a(t), \tau} \int_{t_0}^T S(t)e^{-\delta(t-t_0)} [u(c(t)) + v(l(t))] \, dt \\
= \max_{c(t), a(t), \tau} \int_{t_0}^T e^{-\delta(t)} [u(c(t)) + v(l(t))] \, dt \\
\max_{c(t), a(t), \tau} \left\{ \int_{t_0}^T e^{-\delta(t)} u(c(t)) \, dt + \int_{t_0}^T e^{-\delta(t)} v(l(t)) \, dt \right\}
\]

subject to:

\[
\dot{a}(t) = ra(t) + \tilde{w}(t, \tau) - c(t) \\
\tilde{w}(t, \tau) = w(t)(1-\varsigma)I(t_0, \tau) + b(t, \tau)I(\tau, T) \\
l_r(t) = l(t)I(t_0, \tau) + 1I(\tau, T) \\
a(t_0) = a_0 \quad a(T) = 0 \quad a(t) \geq 0 \forall t \geq \tau
\]

Where,

\( \tau \) is retirement age

\( S() \) is the survival function and \( h(, ) \) is the mortality hazard function, i.e.

\[
S(t) = \exp \left( -\int_{t_0}^t h(s)ds \right) \\
e^{-\delta(t)} = S(t)e^{-\delta(t-t_0)} \text{ is the discount factor that takes into account the subjective discount rate and the survival probability}
\]

\( a(t) : [t_0, T] \rightarrow R^+ \) is savings in \( t \)

\( r \) is the market interest rate (assumed constant)

\( l(t) \) is leisure, normalized to 1 for \( t \geq \tau \)

\( w(t) \) is the salary at age \( t \)

\( \varsigma \) are the payroll taxes

\( b(t, \tau) \) is pension received in \( t \) with retirement in \( \tau \).
\( I(t, t') \) is a dummy equal to 1 when the period is between \( t \) and \( t' \).

It can be shown that individuals will deplete their assets before the maximum age individuals can be alive (Leung, 2000). This is called "the wealth depletion time" and will be denoted as \( \bar{t} \).

The model is solved in three stages. In the first stage, the best consumption path is chosen for given retirement age and wealth depletion time. In the second stage, the optimal wealth depletion time is chosen. Finally, the model is solved for the optimum age of retirement.

Solving, it can be shown that the marginal utility of postponing retirement is:

\[
\frac{d}{d\tau} V(\tau) = \lambda e^{-r(t-t_0)} y'(\tau) - e^{-\beta(\tau)} \Delta v(\tau)
\]

Where

\[
y'(\tau) = w(\tau)(1 - \varsigma) - bI(\tau \geq \tau_m) + b' A(\bar{\tau}, \bar{t})
\]

\[
A(\bar{\tau}, \bar{t}) = \int_{\bar{\tau}}^{\bar{t}} e^{-r(t-\tau)} dt + e^{-r(T-\tau)} \int_{\bar{t}}^{T} e^{-(\tilde{\beta}(t)-\tilde{\beta}(\bar{t}))} dt
\]

Where

\( \tau_m \) is the minimum age to be eligible for a pension
\( \bar{\tau} = \max(\tau_m, \tau_m) \)
\( b' \) is the expected increase in pension if retirement is postponed

Notice that \( y'(\tau) \) is the change in the current value of wealth associated to postponing retirement an instant in \( \tau \). This wealth change is discounted to the initial moment \( t_0 \) at the rate \( r \) and is multiplyed to the co-state variable \( \lambda \), which is the marginal utility of wealth in the optimum path at \( t_0 \).

The term \( \Delta v(\tau) \) is the change in leisure. At retirement, the individual switches from having \( l_r \) to all his time as leisure. This utility change is discounted to \( t_0 \) using the subjective discount rate and the survival probability.

Therefore, in Jiménez-Martín and Sánchez-Martín’s model, the probability that an individual retires is greater the lower is marginal utility of
working. The postponement of retirement has two basic effects in utility: (i) it modifies the budget constraint and hence the consumption of goods and (ii) it reduces leisure. Equation (2) formalizes this relationship.

Note that the second term in the equation (2) is always negative, since the utility of leisure is larger than the utility of working. Hence if it were just because of leisure, individuals would retire as soon as possible. The reason they do not retire immediately is that by working more individuals can raise earnings, compensating for the utility loss stemming from less leisure.

At the optimum, $y'(\tau)$ must be positive. This variable contains three terms. First, $w(\tau)(1 - \zeta)$ is the wage net of contributions that the individual get when he works more time. In turn, $bI(\tau \geq \tau_m)$ is the pension loss from postponing retirement.\footnote{Notice that the loss occurs only if the retirement age being considered is larger than the pension eligibility age, which depends on age and years of service.} Finally, $b'$ is the expected pension growth stemming from postponing retirement, and $A(\tilde{\tau}, \tilde{l})$ converts this per period gain in a discounted sum across time.

4 Estimation of the model

The estimation strategy consists of comparing the optimal retirement decision (according to the model) with observed retirement and choose the preference parameters to maximize the likelihood of having observed the sample. We follow Jiménez-Martín and Sánchez-Martín (2007), but with two modifications:

- We assume that the wealth depletion time is the last moment in the horizon of individuals.

- We adapt the model to the Uruguayan social security idiosyncracies and the information available in our database.
4.1 Solution of the structural model

To obtain a closed form solution to equation (2) it is necessary to choose a functional form for the utility function. We assume that utility derived from consumption can be represented with a CRRA function: \( u(c) = \frac{c^{1-\eta}}{1-\eta} \). With this specification, \( \eta \) is the relative risk aversion coefficient and is one of the key parameters to be estimated.

With the CRRA specification, it is possible to find closed analytic solutions for the marginal utility of wealth \( \lambda = \lambda(t_0) \):

\[
\lambda(t_0) = \left[ \frac{C_c(t)}{Y(t,\bar{t})} \right]^\eta
\]  

(3)

Where

\[
C_c(t) = \int_{t_0}^{\bar{t}} e^{-r(t-t_0)} [S(t)d(t)]^\gamma \, dt
\]

\[
Y(t,\bar{t}) = a_0 + \int_{t_0}^{\tau} e^{-r(t-t_0)} w(t) \left( 1 - \zeta \right) dt + \int_{\tau}^{\bar{t}} e^{-r(t-t_0)} b(t, \tau) dt
\]

The model allows for the computation of the decision in any moment in the life cycle provided the accumulated assets up to that point are observed. However, neither ours nor Jiménez-Martín and Sánchez-Martín databases contain information about assets. They propose to consider \( t_0 \) at the age of 20 and assume that \( a_0 = 0 \). With this assumption, \( Y(\tau,\bar{t}) \) can be computed knowing the flow of wages and pensions.

We only observe wages between 1996 and 2004 and do not directly observe pensions. To complete the flow of labor income, we estimate an econometric model to impute wages in years out of the window of observation. We then estimate pensions using these wages and the rules of the system.

Regarding leisure in the utility function, we assume that the utility change due to postponement of retirement \( \Delta v(\tau) \) has a deterministic component \( \Delta v_D(\tau) \), which we assume linear in some observable characteristics, and an unobserved time-invariant individual component \( \varepsilon \):

\[
\Delta v(\tau) = \Delta v_D(\tau) + \varepsilon \quad \varepsilon \sim F_\varepsilon(.)
\]
\(F_\varepsilon(.)\) is the distribution function of \(\varepsilon\), which is assumed standard normal.

Thus, the marginal utility of postponing retirement at \(\tau\) is defined as

\[
\Gamma(\tau) = \lambda e^{\theta(\tau) - r\tau} y'(\tau) - \Delta \nu_D(\tau) - \varepsilon = \Gamma^*(\tau) - \varepsilon
\]

(4)

In an interior solution (with continuous \(y\)) \(\Gamma^*(\tau^*) = \varepsilon\) and \(\Gamma'(\tau^*) < 0.\)

The probability that an individual is active in \(t\) is equal to the probability that the unobserved component of utility of leisure is smaller than the threshold \(\Gamma^*(\tau^*)\):

\[
P(\tau^* > t) = P(\varepsilon < \Gamma^*(\tau^*)) = F_\varepsilon(\Gamma^*(t)) \tag{5}
\]

### 4.2 Implementation of the model

To facilitate the estimation procedure, we develop a discrete time version of the model.

We also assume that the wealth depletion time coincides with the moment at which the survival probability is zero, i.e. we estimate the model with the restriction \(\bar{\tau} = T\). With this restriction, we can considerably simplify the expressions for \(C_c(\bar{\tau}), Y(\tau, \bar{\tau})\) and \(A(\bar{\tau}, \bar{\tau})\).

First, \(C_c(\bar{\tau} = T) = C_c(T) = \int_{t_0}^T e^{-r(t-t_0)} [S(t) d(t)]^\gamma \, dt\). In discrete time,

\[
C_c(T) = \sum_{s=t_0}^{T} \frac{1}{(1+r)^{t-s}} \left[ S(s) \frac{1}{1+(\delta-r)(s-t_0)} \right]^\frac{\gamma}{\eta}. \tag{5}
\]

Notice that, with this assumption, \(C_c(T)\) depends on the preference parameters \((\eta, \delta)\), the interest rate \((r)\) and the survival function \((S(s))\). Then, assuming that \(\eta, \delta\) is the same for all individuals, \(C_c(T)\) is a constant for each sex.

In turn, \(Y(\tau, \bar{\tau} = T)\) can be written as \(a_0 + \int_{t_0}^T e^{-r(t-t_0)} w(t) (1 - \zeta) \, dt + \int_{\tau}^T e^{-r(t-t_0)} b(t, \tau) \, dt\) for \(\bar{\tau} = T\) and its discrete time version is

\[
a_0 + \sum_{s=t_0}^{T} \frac{1}{(1+r)^{t-s}} w(s) (1 - \zeta) + \frac{1}{(1+r)^{s-t_0}} \sum_{s=\tau+1}^{T} \frac{1}{(1+r)^{s-\tau}} b(s, \tau). \]

Notice that

\[\text{We cannot rule out discontinuities in } y, \text{ like the ones that arise if the individual becomes eligible for a benefit when he postpones retirement.}\]
this term presents individual heterogeneity and for each individual it varies with the retirement age but it does not depend on any unknown.

Finally, $A(\tau,T)$ turns into $\int_{\tau}^{T} e^{-r(t-\tau)} dt = \frac{1-\exp(-r(T-\tau))}{r}$, which expressed in discrete time is $\frac{1-(1+r)^{-(T-\tau)}}{r}$ which depends only on the retirement age $\tau$.

The assumption $\bar{t} = T$ does impact on the above mentioned terms, but this is second order. In turn, it is a useful simplification because we do not need to solve the model for $\bar{t}$, solution that is very intensive in computation.

### 4.3 Maximum likelihood estimation

We define in the first place an indicator variable for the retirement moment:

$$d_{it} = \begin{cases} 1 & \text{if the individual retires at age } t \\ 0 & \text{otherwise} \end{cases}$$

The contribution of each individual $i$ in period $t$ to likelihood is given by:

$$L^i_t(\theta) = \left[1 - \frac{F_{it}}{F_{it-1}}\right]^{d_{it}} \left[\frac{F_{it}}{F_{it-1}}\right]^{1-d_{it}}$$

Where $F_{it}$ is the probability that individual $i$ is still active in $t$ and can be determined from equation (5) as: $F_{it} = F_{i}(\Gamma^*(t)) = \Phi(\Gamma^*_i(t^i, x_{it}; \theta))$, where $\Phi(.)$ is the standard normal cumulative distribution function of a random variable, $\Gamma^*_i$ is the function defined by equation (4), $t^i$ is individual $i$ age in $t$, $x_{it}$ is a set of observable variables of individual $i$ in $t$ and $\theta$ is a vector of unknown parameters.

We work with a sample of individuals who retired between 55 and 70 years of age. Therefore, the contribution of individual $i$ to likelihood of the sample is:

$$L^i(\theta) = \prod_{t=55}^{p} \left[1 - \frac{F_{it}}{F_{it-1}}\right]^{d_{it}} \left[\frac{F_{it}}{F_{it-1}}\right]^{1-d_{it}}$$

$$= \left[\frac{F_{ip-1} - F_{ip}}{F_{i55}}\right]$$
where $p = \min(\tau, 70)$ is the age at which we observe that the individual retires.

In order to estimate the model, we need to complete the specification of $\Gamma^*(\tau)$ so we have to define the deterministic component of utility associated to leisure. Jiménez-Martín and Sánchez-Martín (2007) assume that this term is linear in three variables: age, education (included as a dummy equal to one for "high" education), the interaction between these two variables and a dummy variable that indicates if the individual receives some transfer from social security different from old-age pensions.

We do not observe education. We include age in a linear form. We also include a proxy for the individuals preference for leisure obtained from a linear probability model for contributions. In that model, the dependent variable is 1 if the individual contributes and 0 otherwise. The model has unobserved individual effects that can be estimated thanks to the panel structure of the database. We use these estimated individual effects in the linear probability model as an explanatory variable in the retirement model. We interpret this variable ($e_i$) as a proxy of the willingness of the individual to work and contribute and thus as a proxy for the disutility of leisure. Finally, we include a dummy variable to control for sex ($h_i = 1$ if male). Thus, the leisure related component in the equation to be estimated is:

$$\Delta v_D(\tau)_{it} = v_0 + v_1 \text{age}_{it} + v_2 e_i + v_3 h_i$$

The complete specification of $F$ is:

$$F(\Gamma_i^*(\tau, x_{it}; \theta) = \Phi(\pi_i(\tau)y'_i(\tau) + v_0 + v_1 \tau + v_2 e_i + v_3 h_i)$$

where,

$$\pi_i(\tau) = \left( \frac{C_c(T_i)}{Y(\tau, T_i)} \right)^{\eta} S(\tau)^{-1} \left( \frac{1 + \delta}{1 + r} \right)^{\tau - 20}$$
\[ C_c(T) = \sum_{s=20}^{T} \frac{1}{(1 + r)^{s-20}} \left[ S(s) \frac{1}{1 + (\delta - r)^{s-20}} \right]^{\frac{1}{\eta}} \]

\[ Y(\tau, T)_i = a_{20} + \sum_{s=20}^{\tau} \frac{1}{(1 + r)^{(s-20)}} w_{s,i} (1 - \varsigma) + \frac{1}{(1 + r)^{(\tau-20)}} \sum_{s=\tau+1}^{T} \frac{1}{(1 + r)^{(s-\tau)}} b_{\tau,i} \]

\[ y_i'(\tau) = w_{\tau,i}(1 - \varsigma) - b_{\tau,i} \times I_{\tau,i} + b'_{\tau,i} A(\tau, T) \]

\[ A(\tau, T) = \frac{1 - (1 + r)^{T-\tau}}{r} \]

and \( a_{20} \) is assets at 20 years of age and is assumed to be zero, \( w_{s,i} \) is the wage of individual \( i \) at age \( s \), \( b_{\tau,i} \) is pension obtained by \( i \) if he retires at age \( \tau \), \( I_{\tau,i} \) is an indicator function equal to 1 if the individual \( i \) is eligible for a pension, \( b'_{\tau,i} A(\tau, T) \) is the sum of pension gains, discounted to \( \tau \), from retiring in \( \tau + 1 \) rather than in \( \tau \).

### 4.4 Parameters and variables

We now single out the vector of parameters to be estimated, the vector of parameters defined out of the model and the observable variables.

First, the parameters to be estimated are

\[ \theta = (\eta, \delta, v_0, v_1, v_2) \] (6)

where \( \eta \) is the coefficient of relative risk aversion, \( \delta \) is the subjective discount rate, \( v_0, v_1, v_2 \) are the coefficients associated to a constant, age, and the proxy for the utility of leisure.

The parameters set out of the model include the interest rate \( (r) \) and the survival function \( (S(s)) \). Also given are the pension eligibility rules, the rules for the computation of the average indexed earnings and the replacement rate.

Regarding observable variables, we have to evaluate them in three different moments: at age 55, at retirement age and one year before retirement.
The vector of variables is thus:

\[(t, w_{i,t}, b_{i,t}, b'_{i,t}, Y_{i,t,T}, e_i, h_i) \text{ with } t = 55, \tau_i, \tau_i - 1.\]

In the next section, we explain how we obtained each of these variables and we present some descriptive statistics.

5 Data

Since the pension reform that began in 1996, Uruguay has administrative records of work histories of affiliates to the BPS. In 2004, BPS gave to the Department of Economics at the university (dECON-FCS-UDELAR) a random sample of about 80,000 contributors. The sample was chosen in December 2004, including individuals who contributed at least once between April 1996 and December 2004. We thus have a panel with up to 105 records by individual.

The database contains some permanent characteristics of individuals (date of birth, sex, nationality, among others), information about their work histories (monthly labor earnings, labor category, worked hours, date of initiation and termination in each firm, and the cause for termination). There is also monthly information about characteristics of the firms: public or private, number of employees and employers and branch of activity. There is information about the date individuals received their first pension, but there is no direct information about the date of retirement. The database has no information about the amount of pensions paid. As already mentioned, we imputed this information using auxiliary models.\(^3\)

We estimated the structural model on a subsample of public employees aged 45 and above in 1996, who were contributing in April 1996, who retired between 1996 and 2004 and whose age was between 55 and 70 at retirement.

\(^3\)For a detailed explanation of the models used to complete work histories, see Forteza et. al. (2009).
Most of these individuals are covered by the social security rules of Acto 9 and the "transition regime" in law 16713.

We chose this subsample for several reasons. First, in the private sector there is underreporting of contribution wages at early stages of the working career and overreporting in the last years, and hence there is considerable error in the measurement of wages. We expect this type of error to be absent or very small in the case of public sector employees.

Second, we only considered individuals who were contributing in April 1996 because only in this case we have the date of the first record in Social Security and therefore, with some additional assumptions, we can have information about the number of years of contribution at each age. By considering a sample of individuals who get a pension at 70 or earlier we focus on the ordinary pension, leaving aside a different path to pensions called the "advanced-age" old age pension, which has different rules.

We present in figure 1 the histogram with the relative frequencies of retirement ages for men and women separately. The main observed difference between sexes is that a considerable number of women retire before 60 years of age. This is consistent with Uruguayan social security rules in the period: the minimum age for retirement for women was 55 and for men 60 at the beginning of the period of observation. There are also picks at 60, 65 and 70, consistent with findings reported in previous papers (Alvarez et al 2009).

In figure 2 we present the pension hazard rate, i.e. the rate of transition from being an active worker to become a pensioner. The rate of pension claims is low -but not zero- and increasing between 55 and 59 years of age among women. This rate grows considerably at 60 and above, reaching 10 percent at 60. It fluctuates around 10 percent between 60 and 67 and rises to 20 percent at 68 and 69. In the case of men, the pension hazard rates are close to zero when individuals are below 60 years of age (which is consistent

---

4 The pension hazard rate is defined as the proportion of the individuals who did not receive their first pension in previous periods (i.e. the population "at risk" of receiving a pension) who get a pension in the current period.
with the legal norms). Between ages 60 and 65 the hazard rate is above 10 percent, with picks at 66, 67 and a larger pick at 70.

5.1 Pension eligibility

We computed the moment the individual becomes eligible for a pension using information from the work history database (age and years of service) and the system norms. We define the eligibility indicator variable as follows:

\[
I_{\tau,i} = \begin{cases} 
1 & \text{individual } i \text{ is eligible at age } \tau \\
0 & \text{otherwise.}
\end{cases}
\]

In table 1, we include the proportion of individuals that were eligible at each age, according to our computations. Even at advanced ages, a considerable proportion of individuals were not eligible. For example at 68 years of age, about 20 percent of women and 30 percent of men were not yet eligible. Table 2 shows the percentage of individuals who got a pension and who were eligible according to our computations. In no case this percentage surpasses 50 percent, showing that \(I_{\tau,i}\) measures eligibility with much error. Two possible reasons for the error are, first, that the years of service is measured with error and, second, that the legal norms are not enforced in practice.

Since measurement of \(I_{\tau,i}\) is crucial for the estimation of the structural model, we considered some options for the computation of this variable:

1. Using the years of service and age required according to the legal norms (Acto 9 and law 16713, depending on the case).

2. Using only the age requirement, i.e. assuming that the years of service requirement is not actually enforced.

3. Using the years of service and age required in the legal norms, but imputing the value 1 in the eligibility indicator variable if the individual was receiving a pension.
5.2 Estimation and imputation of flows of wages and pensions

In order to have wages for the whole life cycle of the individuals in the sample \( \{w_{i,t}\}_{i=1,...,N, t=20,...,T} \), we estimated an auxiliary model. We considered the observed salary in the window of observation and imputed a salary in other periods. We estimated a model for the imputation, which includes age and squared age and allows for unobserved individual effects. We then computed the individual effects as the mean of the residuals by individual. These individual effects are expected to capture heterogeneity that is not observed in our database, mainly education and habilitiy (Forteza et. al. 2009). To obtain a prediction equation, we estimated the model in a second step using the individual effects computed in the first step. In table 3, we present the results of estimating this model with OLS.\(^5\) The specification 2 includes the individual effects computed from specification 1. As expected, the R2 in specification 2 is high, due to the inclusion of estimates for the individual effects. This procedure would not be appropriate to do inference, so we do not comment on the values of the parameters, but the estimated models look appropriate for predictive purposes.

Once we have the wage flow for each individual and having information about age and years of service we could compute \( b_{i,\tau} \), the pension that individual \( i \) would obtain if he retired at age \( \tau \) and hence the present value of that flow. The net present value of the flow of pensions is

\[
V_{PN}(i, \tau) = \sum_{t=\tau}^{T} \frac{S(t)}{S(\tau)} \left( \frac{1 + tcj}{1 + r} \right)^{t-\tau} b_{i,\tau} \times I_{t,i}
\]

where \( tcj \) is the expected annual growth in the real value of pensions after retirement.

\(^5\)Notice that our database is not top censored as it is often the case in SS datasets.
Then we define:

\[ \Delta VP_N(i, \tau) = \left( \frac{S(\tau + 1)}{S(\tau)} \frac{1}{1+r} \right) VP_N(i, \tau + 1) - VP_N(i, \tau) \]
\[ = -b_{r,i} \times T_{r,i} + b_{r,i}' A(\tau, T) \]

We now have all the needed components for the estimation.

6 Results

We include in tables 4 to 6 the results of the structural estimation with the alternative assumptions about eligibility.

In table 4, we present the results obtained when eligibility is computed assuming strict enforcement of social security norms. We first estimate a model with all the parameters defined in (6) free. The results indicate that the information is not enough to estimate the preference parameters accurately. The estimated coefficients of relative risk aversion (CRRA) and subjective discount rate (SDR) are not significantly different from zero and the confidence intervals are very wide ( (-10.7, 27.2) for the CRRA and (-6.6,10.2) for the SDR). This result is not very surprising since identifying the SDR in structural models is often an issue. Because of this, we proceeded to estimate the model for a given SDR, doing sensitivity analysis with several alternatives for this parameter: 0.10, 0.07, 0.05, 0.04 and 0.03. It can be seen that the estimated values for the other parameters and the log-likelihood are not very sensitive to the value chosen for the SDR.

The estimated CRRA is about 2.3, and the confidence interval varies slightly depending on the value of the SDR, suggesting that agents are moderately risk averse. The other coefficients are significant and with the expected sign: the probability of retiring rises with age, is lower for men than for women and is lower the smaller is the utility of leisure.

We present in table 5 the results obtained when the eligibility is defined taking into account only age. The results are basically the same as in table
4, with the exception of the CRRA parameter in the regression with SDR free, which is now significantly different from zero and equal to 2.27 with a confidence interval 0.5 to 4.0. There are no large changes in the signification and sign of other parameters.

Finally, in table 6 we present the results obtained when we consider eligibility according to existing rules, but imputing that the individual is eligible if we observe he is receiving a pension. Both the CRRA and the SDR are significantly different from zero in this case, but the estimated value for the SDR is negative, which is not plausible. The estimations of the CRRA with the various imputed values for the SDR are slightly smaller to what we got in the other two cases. The CRRA is 1.8 when the SDR is set at 0.05.

7 Simulations

Using the parameters estimated in the structural model, we simulated retirement in five different scenarios. The benchmark scenario has the norms in effect in the observed period, with some individuals covered by the norms of the Acto 9 and others by the transition regime in law 16713. This simulation is useful to assess to what extent the model is able to replicate the observed behavior, so it can be used to assess goodness of fit. We also use the benchmark scenario as a reference point to assess the impact of policy changes we simulate in the other four scenarios.

We simulate a second scenario in which we assume there is no reform in 1995: all individuals continue covered by the rules in the Acto 9 passed in 1979. In the third scenario, we assume that all individuals switch to the transition regime in 1996. In the fourth scenario, we apply all the norms that were in effect between 1996 and 2004, with the exception of the minimum retirement age for women, which we assume to remain unchanged, i.e. to remain at 55. Finally, in the fifth scenario we assume that the years of service required to access a pension remained at 30, rather than increasing
to 35 as set in law 16713 in 1995. This scenario partially mimicks a reform passed in 2008. Each scenario was repeated ten times.

The benchmark scenario adequately replicates the observed data, particularly regarding the central values of the distribution. The average age at retirement observed in the sample is 62.8 years and the simulated average age is 63.0 (table 7). Women retire at a smaller age (61.4 and 63.6, women and men respectively) and the simulation also replicates this values accurately. The median observed and simulated retirement ages are 62 and 63, for women and men respectively. Fitness is somehow weaker at the lower tail of the distribution. The percentile 10 retirement age is 58 for observed and 60 for simulated data. The survival functions (figure 4) and the histograms for the observed and simulated retirement ages in the benchmark scenario (figure 3) show the underestimation of retirement in the model before age 60. The counterpart is the overestimation of the pick of retirement at 60. Several individuals who retired before 60 are predicted to retire at 60 according to the model. We observe in particular some men who retired before 60, something that the model cannot replicate because the norms we considered do not allow for this. This early retirement that the model is not capturing correctly may be due to disability and "bonification" of periods of service. As mentioned above, we only modeled the ordinary old-age pension, so we did not model disability. Also there are some activities for which each year of work and age count as more than one year for pension purposes. These are the so-called "bonus" activities. We did not consider these cases in this version of the model. Teaching is one of the activities with "bonus" and there is a large number of teachers among public employees. We plan to deal with this issue in the next version of this paper.

The results obtained in the other scenarios show a very small sensitivity of retirement age to the reforms in social security (table 7). Neither mean age, nor percentiles 10, 50 and 90 show large changes across scenarios. Most individuals do not change the age of retirement across scenarios. In no case
did the retirement age change relative to the benchmark scenario in more than 6 percent of individuals and in most cases this percentage is even lower.

8 Conclusions

In this paper we estimated a structural model for retirement decisions of public employees using administrative records from social security in the main pension program of Uruguay. We used the model proposed by Jiménez-Martín and Sánchez-Martín (2007) with some modifications. First, we made the simplifying assumption that the wealth depletion time coincides with the last year in the horizon of the individuals. Second, we adapted the model to the characteristics of the local social security system and data availability.

We find that the information in the sample is not sufficient to jointly estimate the coefficient of relative risk aversion and the subjective discount rate. However, imposing plausible values for the subjective discount rate (10, 7, 5, 4 and 3 percent), we could estimate the CRRA parameter with considerable accuracy. This estimation proved robust to the various values used for the subjective discount rate.

The estimated CRRA is about 2, which means that individuals are moderately risk averse. The estimations also show that the probability of retirement is higher for individuals with smaller propensity to contribute (measured through a proxy for the utility of leisure), is higher for women than men and increases with age.

The retirement ages simulated in the benchmark scenario replicate well the observed data, particularly in terms of means and medians. However, the model seems to underestimate retirement before 60 years of age, probably because disability and "bonus" activities are not considered in our model. We are currently working to solve this issue.

We simulated several additional scenarios, including a non-reform scenario, one in which all individuals are immediately switched to the new
regime introduced in 1995, one with the norms in effect in the period with
the exception of the minimum retirement age of women which was kept at
55 and finally one scenario that maintains the 30 years of service required for
pension eligibility. In none of these scenarios do we find important changes in
the simulated age of retirement. According to the model, retirement decision
is not very sensitive to the policy options considered in this paper.

References

trabajadores uruguayos y la seguridad social. Revista de Economía, Vol
16(2), pp 147-184

al retiro genera la seguridad social? El caso uruguayo. Cuadernos de
Economía, 47, 217-247.

cess to contributory pensions. The case of Uruguay. Journal of Pension

Encourage Work Among Older Americans. Boston Papers in Economics.


Journal of Political Economy, 10, 783-802.

[7] Forteza, A., I. Apella, E. Fajnzylber, C. Grushka, I. Rossi and G. San-
román. 2009. Work Histories and Pension Entitlements in Argentina,
Chile and Uruguay. Social Protection Discussion Papers 0926. Washing-


Figure 1: Retirement Age (public sector employees)

Note: The sample includes female and male public sector employees, older than 45 years in 1996, who were contributing in April 1996, retired in the period 1996-2004 and were between 55 and 70 years old when they retired.

Source: Authors’ computation based on BPS data.
Figure 2: Retirement hazard rates

Note: The hazard rates are obtained as the proportion of those who retire at certain age given they had not retired before.
Source: Authors’ computation based on BPS data.
Figure 3: Observed and simulated age of retirement

Source: Authors’ computation based on BPS data.
Figure 4: Survival rates

Note: Survival rates in the pool of active population conditional on being active at 55.
Source: Authors’ computation based on BPS data.
Figure 5: Retirement Age by Sex

Source: Authors’ computation based on BPS data.
Table 1: Percentage of contributors who are eligible for pensions. By age and sex.

<table>
<thead>
<tr>
<th>Age</th>
<th>Females</th>
<th>Males</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>10.4</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>56</td>
<td>10.4</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>57</td>
<td>10.3</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>58</td>
<td>10.4</td>
<td>0.0</td>
<td>3.5</td>
</tr>
<tr>
<td>59</td>
<td>39.6</td>
<td>0.0</td>
<td>13.3</td>
</tr>
<tr>
<td>60</td>
<td>46.2</td>
<td>54.0</td>
<td>51.4</td>
</tr>
<tr>
<td>61</td>
<td>46.9</td>
<td>51.1</td>
<td>49.7</td>
</tr>
<tr>
<td>62</td>
<td>50.5</td>
<td>49.8</td>
<td>50.0</td>
</tr>
<tr>
<td>63</td>
<td>55.2</td>
<td>49.3</td>
<td>51.3</td>
</tr>
<tr>
<td>64</td>
<td>59.5</td>
<td>50.2</td>
<td>53.3</td>
</tr>
<tr>
<td>65</td>
<td>63.3</td>
<td>52.7</td>
<td>56.2</td>
</tr>
<tr>
<td>66</td>
<td>69.0</td>
<td>57.1</td>
<td>61.1</td>
</tr>
<tr>
<td>67</td>
<td>74.8</td>
<td>60.6</td>
<td>65.4</td>
</tr>
<tr>
<td>68</td>
<td>79.2</td>
<td>67.3</td>
<td>71.3</td>
</tr>
<tr>
<td>69</td>
<td>82.2</td>
<td>71.4</td>
<td>75.0</td>
</tr>
<tr>
<td>70</td>
<td>84.0</td>
<td>76.4</td>
<td>78.9</td>
</tr>
</tbody>
</table>

Source: Authors’ computation based on BPS data.
Table 2: Percentage of retired individuals who were eligible for pensions according to legal norms. By retirement age and sex.

<table>
<thead>
<tr>
<th>Age</th>
<th>Females</th>
<th>Males</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>56</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>57</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>58</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>59</td>
<td>12.5</td>
<td>0.0</td>
<td>8.8</td>
</tr>
<tr>
<td>60</td>
<td>26.3</td>
<td>34.6</td>
<td>31.9</td>
</tr>
<tr>
<td>61</td>
<td>19.4</td>
<td>36.1</td>
<td>31.6</td>
</tr>
<tr>
<td>62</td>
<td>33.3</td>
<td>28.0</td>
<td>29.4</td>
</tr>
<tr>
<td>63</td>
<td>44.0</td>
<td>22.2</td>
<td>27.8</td>
</tr>
<tr>
<td>64</td>
<td>44.4</td>
<td>41.7</td>
<td>42.4</td>
</tr>
<tr>
<td>65</td>
<td>37.5</td>
<td>32.1</td>
<td>33.3</td>
</tr>
<tr>
<td>66</td>
<td>21.4</td>
<td>28.1</td>
<td>26.8</td>
</tr>
<tr>
<td>67</td>
<td>22.2</td>
<td>26.8</td>
<td>26.0</td>
</tr>
<tr>
<td>68</td>
<td>50.0</td>
<td>23.5</td>
<td>28.6</td>
</tr>
<tr>
<td>69</td>
<td>30.0</td>
<td>38.9</td>
<td>35.7</td>
</tr>
<tr>
<td>70</td>
<td>44.4</td>
<td>28.9</td>
<td>31.9</td>
</tr>
</tbody>
</table>

Source: Authors’ computation based on BPS data.
Table 3: Wage prediction equation
Dependent Variable: Real wages (in logs, deflated by Average Wage Index May 1995=100)

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Age</td>
<td>0.133***</td>
<td>0.133***</td>
</tr>
<tr>
<td></td>
<td>[42.01]</td>
<td>[95.02]</td>
</tr>
<tr>
<td>Age^2/10</td>
<td>-0.014***</td>
<td>-0.014***</td>
</tr>
<tr>
<td></td>
<td>[40.10]</td>
<td>[89.76]</td>
</tr>
<tr>
<td>Individual effect</td>
<td>1.000***</td>
<td>1.000***</td>
</tr>
<tr>
<td></td>
<td>[350.33]</td>
<td>[334.66]</td>
</tr>
<tr>
<td>Constane</td>
<td>3.202***</td>
<td>3.176***</td>
</tr>
<tr>
<td></td>
<td>[45.50]</td>
<td>[102.15]</td>
</tr>
<tr>
<td>Observations</td>
<td>29769</td>
<td>29769</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.06</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Robust t-statistics in brackets
*** significant at 1, ** significant at 5, * significant at 10
Table 4: Estimates from the structural model (under type 0 eligibility rules) /1

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDR /2</td>
<td>1.813</td>
<td>0.10</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>[4.286]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRRA</td>
<td>8.209</td>
<td>2.440***</td>
<td>2.343***</td>
<td>2.287***</td>
<td>2.263***</td>
<td>2.240***</td>
</tr>
<tr>
<td></td>
<td>[9.678]</td>
<td>[0.247]</td>
<td>[0.260]</td>
<td>[0.267]</td>
<td>[0.269]</td>
<td>[0.270]</td>
</tr>
<tr>
<td>eta leisure /3</td>
<td>1.427***</td>
<td>1.431***</td>
<td>1.431***</td>
<td>1.432***</td>
<td>1.432***</td>
<td>1.432***</td>
</tr>
<tr>
<td></td>
<td>[0.196]</td>
<td>[0.196]</td>
<td>[0.196]</td>
<td>[0.196]</td>
<td>[0.196]</td>
<td>[0.196]</td>
</tr>
<tr>
<td>Age</td>
<td>-0.311***</td>
<td>-0.311***</td>
<td>-0.311***</td>
<td>-0.311***</td>
<td>-0.311***</td>
<td>-0.311***</td>
</tr>
<tr>
<td></td>
<td>[0.00883]</td>
<td>[0.00883]</td>
<td>[0.00883]</td>
<td>[0.00883]</td>
<td>[0.00883]</td>
<td>[0.00883]</td>
</tr>
<tr>
<td>Male</td>
<td>0.622***</td>
<td>0.614***</td>
<td>0.614***</td>
<td>0.614***</td>
<td>0.614***</td>
<td>0.614***</td>
</tr>
<tr>
<td></td>
<td>[0.0789]</td>
<td>[0.0790]</td>
<td>[0.0790]</td>
<td>[0.0790]</td>
<td>[0.0790]</td>
<td>[0.0790]</td>
</tr>
<tr>
<td>Constant</td>
<td>18.95***</td>
<td>18.94***</td>
<td>18.94***</td>
<td>18.94***</td>
<td>18.94***</td>
<td>18.94***</td>
</tr>
<tr>
<td></td>
<td>[0.553]</td>
<td>[0.554]</td>
<td>[0.554]</td>
<td>[0.554]</td>
<td>[0.554]</td>
<td>[0.554]</td>
</tr>
<tr>
<td>Nobs</td>
<td>867</td>
<td>866</td>
<td>866</td>
<td>866</td>
<td>866</td>
<td>866</td>
</tr>
<tr>
<td>Log-likelihood.</td>
<td>-2186</td>
<td>-2184</td>
<td>-2184</td>
<td>-2184</td>
<td>-2184</td>
<td>-2184</td>
</tr>
</tbody>
</table>

Standard errors in brackets
*** significant at 1, ** significant at 5, * significant at 10

/1 Type 0 eligibility considers the actual rules of the Uruguayan SS system in terms of age and years of contribution at the time when the individual retired.
/2 The subjective discount rate is an estimated parameter in column 1 and a fixed constant in the other columns.
/3 eta leisure is a proxy of the utility from leisure. The lower eta leisure the greater the preference for leisure.
Table 5: Estimates from the structural model (under type 1 eligibility rules) /1

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDR /2</strong></td>
<td>-0.105</td>
<td>0.10</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>RRA</strong></td>
<td>2.270***</td>
<td>2.392***</td>
<td>2.279***</td>
<td>2.215***</td>
<td>2.187***</td>
<td>2.162***</td>
</tr>
<tr>
<td></td>
<td>[0.893]</td>
<td>[0.134]</td>
<td>[0.130]</td>
<td>[0.128]</td>
<td>[0.126]</td>
<td>[0.125]</td>
</tr>
<tr>
<td><strong>eta_leisure /3</strong></td>
<td>1.453***</td>
<td>1.466***</td>
<td>1.466***</td>
<td>1.466***</td>
<td>1.466***</td>
<td>1.466***</td>
</tr>
<tr>
<td></td>
<td>[0.213]</td>
<td>[0.214]</td>
<td>[0.214]</td>
<td>[0.214]</td>
<td>[0.214]</td>
<td>[0.214]</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>-0.309***</td>
<td>-0.308***</td>
<td>-0.308***</td>
<td>-0.308***</td>
<td>-0.308***</td>
<td>-0.308***</td>
</tr>
<tr>
<td></td>
<td>[0.00923]</td>
<td>[0.00924]</td>
<td>[0.00924]</td>
<td>[0.00924]</td>
<td>[0.00924]</td>
<td>[0.00924]</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>0.443***</td>
<td>0.437***</td>
<td>0.437***</td>
<td>0.437***</td>
<td>0.437***</td>
<td>0.437***</td>
</tr>
<tr>
<td></td>
<td>[0.0869]</td>
<td>[0.0870]</td>
<td>[0.0870]</td>
<td>[0.0870]</td>
<td>[0.0870]</td>
<td>[0.0870]</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>18.93***</td>
<td>18.92***</td>
<td>18.92***</td>
<td>18.92***</td>
<td>18.92***</td>
<td>18.92***</td>
</tr>
<tr>
<td></td>
<td>[0.582]</td>
<td>[0.582]</td>
<td>[0.582]</td>
<td>[0.582]</td>
<td>[0.582]</td>
<td>[0.582]</td>
</tr>
<tr>
<td><strong>Nobs</strong></td>
<td>758</td>
<td>757</td>
<td>757</td>
<td>757</td>
<td>757</td>
<td>757</td>
</tr>
<tr>
<td><strong>Log-likelihood.</strong></td>
<td>-1924</td>
<td>-1922</td>
<td>-1922</td>
<td>-1922</td>
<td>-1922</td>
<td>-1922</td>
</tr>
</tbody>
</table>

Standard errors in brackets
*** significant at 1, ** significant at 5, * significant at 10

/1 Type 1 eligibility considers the rules of the Uruguayan SS system only in terms of age, with no condition regarding years of service.

/2 The subjective discount rate is an estimated parameter in column 1 and a fixed constant in the other columns.

/3 eta_leisure is a proxy of the utility from leisure. The lower eta_leisure the greater the preference for leisure.
Table 6: Estimates from the structural model (under type 2 eligibility rules) /1

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SDR /2</strong></td>
<td>-0.200***</td>
<td>0.1</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>[0.00233]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RRA</strong></td>
<td>2.069***</td>
<td>2.011***</td>
<td>1.869***</td>
<td>1.785***</td>
<td>1.748***</td>
<td>1.715***</td>
</tr>
<tr>
<td></td>
<td>[0.00994]</td>
<td>[0.0056]</td>
<td>[0.0055]</td>
<td>[0.0054]</td>
<td>[0.0054]</td>
<td>[0.00539]</td>
</tr>
<tr>
<td><strong>eta leisure /3</strong></td>
<td>1.520***</td>
<td>1.443***</td>
<td>1.447***</td>
<td>1.450***</td>
<td>1.452***</td>
<td>1.454***</td>
</tr>
<tr>
<td></td>
<td>[0.216]</td>
<td>[0.199]</td>
<td>[0.199]</td>
<td>[0.200]</td>
<td>[0.200]</td>
<td>[0.200]</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>-0.270***</td>
<td>-0.306***</td>
<td>-0.305***</td>
<td>-0.304***</td>
<td>-0.303***</td>
<td>-0.303***</td>
</tr>
<tr>
<td></td>
<td>[0.00933]</td>
<td>[0.00885]</td>
<td>[0.00885]</td>
<td>[0.00885]</td>
<td>[0.00885]</td>
<td>[0.00885]</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>0.772***</td>
<td>0.652***</td>
<td>0.661***</td>
<td>0.668***</td>
<td>0.672***</td>
<td>0.676***</td>
</tr>
<tr>
<td></td>
<td>[0.0866]</td>
<td>[0.0802]</td>
<td>[0.0805]</td>
<td>[0.0807]</td>
<td>[0.0808]</td>
<td>[0.0809]</td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td>16.10***</td>
<td>18.57***</td>
<td>18.48***</td>
<td>18.41***</td>
<td>18.37***</td>
<td>18.32***</td>
</tr>
<tr>
<td></td>
<td>[0.596]</td>
<td>[0.555]</td>
<td>[0.556]</td>
<td>[0.556]</td>
<td>[0.556]</td>
<td>[0.556]</td>
</tr>
<tr>
<td><strong>Nobs</strong></td>
<td>865</td>
<td>864</td>
<td>864</td>
<td>864</td>
<td>864</td>
<td>864</td>
</tr>
<tr>
<td><strong>Log-likelihood.</strong></td>
<td>-1924</td>
<td>-2101</td>
<td>-2082</td>
<td>-2067</td>
<td>-2060</td>
<td>-2052</td>
</tr>
</tbody>
</table>

Standard errors in brackets
*** significant at 1, ** significant at 5, * significant at 10

/1 Type 2 eligibility considers the actual rules of the Uruguayan SS system in terms of age and years of contribution at the time when the individual retired but imputing the value 1 to eligibility at the moment when retirement is actually observed.

/2 The subjective discount rate is an estimated parameter in column 1 and a fixed constant in the other columns.

/3 etaleisure is a proxy of the utility from leisure. The lower etaleisure the greater the preference for leisure.
Table 7: Retirement age

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>P10</th>
<th>Median</th>
<th>P90</th>
<th>No changes /1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>62.8</td>
<td>58</td>
<td>62</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td>63.0</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Only “Acto 9”</td>
<td>62.9</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>95.46%</td>
</tr>
<tr>
<td>Only “Transition”</td>
<td>63.0</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>97.37%</td>
</tr>
<tr>
<td>Benchmark + minimum age Acto 9</td>
<td>63.0</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>99.27%</td>
</tr>
<tr>
<td>Benchmark + 2008 reform</td>
<td>63.0</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>99.95%</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>61.4</td>
<td>57</td>
<td>61</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td>61.7</td>
<td>57</td>
<td>62</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Only “Acto 9”</td>
<td>61.7</td>
<td>57</td>
<td>62</td>
<td>66</td>
<td>97.50%</td>
</tr>
<tr>
<td>Only “Transition”</td>
<td>61.7</td>
<td>57</td>
<td>62</td>
<td>66</td>
<td>100.00%</td>
</tr>
<tr>
<td>Benchmark + minimum age Acto 9</td>
<td>61.7</td>
<td>57</td>
<td>62</td>
<td>66</td>
<td>97.84%</td>
</tr>
<tr>
<td>Benchmark + 2008 reform</td>
<td>61.7</td>
<td>57</td>
<td>62</td>
<td>66</td>
<td>99.93%</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observed</td>
<td>63.6</td>
<td>60</td>
<td>63</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Benchmark</td>
<td>63.6</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Only “Acto 9”</td>
<td>63.5</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>94.43%</td>
</tr>
<tr>
<td>Only “Transition”</td>
<td>63.7</td>
<td>60</td>
<td>64</td>
<td>67</td>
<td>96.04%</td>
</tr>
<tr>
<td>Benchmark + minimum age Acto 9</td>
<td>63.6</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>100.00%</td>
</tr>
<tr>
<td>Benchmark + 2008 reform</td>
<td>63.6</td>
<td>60</td>
<td>63</td>
<td>67</td>
<td>99.97%</td>
</tr>
</tbody>
</table>

Note: /1 Percentage of observations that do not change relative to the benchmark