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NEW TOOLS IN MICROMODELING RETIREMENT DECISIONS: OVERVIEW AND APPLICATIONS TO THE ITALIAN CASE

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NEW TOOLS IN MICROMODELING RETIREMENT DECISIONS: OVERVIEW AND APPLICATIONS TO THE ITALIAN CASE

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Abstract

The aging process and the reduction of labor-force participation are matters of much concern in most developed countries, especially for their implication on the sustainability of Social Security systems and for tackling poverty, just to mention few topics. For this reasons the literature on retirement has developed dramatically in the last decades and, thanks to improved computer power and to data availability, the estimation techniques are getting realistic and the fields of application are constantly increasing. In this paper I present an overview of the most recent developments in micromodeling retirement decisions and discuss the main advantages and disadvantages of each approach; in particular, I put an emphasis on the trade-off between the degree of realism of hypotheses, on the one hand, and data tractability and/or estimation performance, on the other hand, affecting the choice of the estimation strategy. I also sketch some of the most relevant topics which deserve more attention in future research. As an example, in the remainder of the article I focus on the Italian case: after presenting some stylized facts and the main results of the applied works assessing the effects of Social Security on agents' choices, I carry out a comparison between two alternative "dynamic" estimation approaches (Duration model and *Option Value* model) and discuss their main implications. In particular, as for the Duration model, I propose several new measures of the wealth accumulation opportunities provided by the Social Security system and assess their role played in determining the timing of retirement of Italian older male employees.

JEL classification: H55, J26, C24

1. Introduction

Modeling retirement decisions has been the subject of a large number of economic and econometric studies over the last decades: the improvement of computer power and the availability of rich microdata (both in the cross sectional and in the longitudinal dimensions) have boosted the number of theoretical and applied works aiming at explaining how individuals decide to join or to leave the labor force, that is, the timing of their retirement. However, besides the improvements on the technological and the information grounds, the interest on such subject has crucially been determined by the scenarios that most developed countries will face in the next future, characterized by high dependency ratios (due to relatively low fertility rates and improved life-expectancies). This dramatic demographic transition has been anticipated by the strong decline of the older cohorts activity rates since

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the middle 1900s, which has been only partially compensated by the increase of number of women joining the labor force in the same period. In fact, this trend has implied that from 1960 till the middle nineties the average fraction of working lifetime in OECD countries has lowered from about two thirds to almost one half (OECD (1995)). For this reasons a number of researchers has been working on the analysis of the determinants of retirement decisions and, in particular, on the role played Social Security. In fact one of the most debated issues is whether and to which extent the existence of early retirement incentives provided by Social Security systems has contributed to the decline of activity rates Although there seems to be little doubt on the fact that the steady increase and the non-linearities of exit rates from labor force have much to do with State pension benefits provision and rules, a debate is still open concerning the actual impact that SS changes have on retirement decisions. For example, as documented in Cole and Gruber (2000), previous literature dating from 1970s has concluded that such changes have a significant, but modest effect on retirement dates in the U.S.. On the other hand and more plausibly, more recent studies have questioned such results, by bringing evidence of a stronger, crucial role played by SS incentives in explaining workers' retirement behavior. The latter approaches, in particular, have pointed out that retirement is, typically, a decision taken by forward looking individuals, who, while maximizing a life-time "revenue" function in an uncertain environment, contrast the present Social Security wealth accumulation opportunities with those at some time in the future. In fact, starting from the work by Stock and Wise (1990) on the *Option Value* of retirement, a number of works have shared this assumption and assessed its relevance by both estimating structural forms (like Rust (1989), Gustman and Steinmeier (1986b) and Rust and Phelan (1997)) and reduced forms of retirement decisions by allowing for forward-looking behavior through the specification of certain SS measures (see Lumsdaine, Stock and Wise (1992), Samwick (1998), Coile and Gruber (2000) and Chan and Stevens (2001)).

In this paper I present an overview of most recent developments in micromodeling retirement decisions and discuss the main advantages and disadvantages of each approach; I also emphasize the trade-off between data tractability and the degree of realism of the hypotheses which strongly affects the choice of any estimation strategy. I also sketch some of the most relevant topics which deserve more attention in future research. As an example, in the remainder of the article I focus on the Italian case. In fact, studies assessing the determinants of retirement are very recent and results are somehow still contradictory. Besides being a deficiency *per se*, such lack of univocal answers impedes any serious forecast about the effectiveness of past and future reforms in improving activity rates. In fact, Italy underwent major reforms in the last decade which have strongly reduced Social Security benefits and changed the life-time pattern of the mentioned incentives. Yet, only few works have investigated the implications of these changes on retirement behavior.

Thus, in the last sections of this work, after presenting the Institutional features of Social Security in Italy and some relevant empirical facts of retirement choices, I carry out a comparison between two alternative estimation approaches and discuss their main implications.

2. Modeling retirement decisions: an overview

Preliminarily, I focus on the meaning of *retirement*: instead of giving a mere definition, which would turn out to be too general and inevitably "loose", I prefer investigating and selecting some of the characteristics which "qualitatively" define retirement. By doing so I aim, on the one hand, at pointing out the reasons why researchers have been treating retirement *differently from the standard choice of labor supply* and, on the other hand, at providing a criterion for model classification.

In short, it can be said that retirement:

1) is a discrete choice, i.e. implies the assessment of two or more alternatives (or states);

2) typically, is an absorbing state (although with a few exceptions);

3) is a decision which can be made (or can be made only) in an age interval defined by the law;

4) implies forward looking behavior (i.e. assessment of future economic incentives);

5) depends on both individual and institutional characteristics- i.e. family composition and wealth, pension formula and eligibility rules, but also on labor market characteristics, health care provision and so on;

6) is a sequential (or dynamic) choice;

7) it is taken in an uncertain context.

Although in many real situations the border-line between labor-supply (either from "static" or "life cycle" standpoint) and retirement decision can be very thin as a worker gets older, the points mentioned above can give a crucial help to decide which approach is more satisfactory for modeling agents decisions. For example, the truer are points 2) and 3), the better is to differentiate retirement from labor supply: in fact, the irreversibility of the decision of leaving the work-force is a characteristic shared by many Social Security systems; this, in turn, rises dramatically the need for a forward looking behavior (point 4) and makes uncertainty relevant as well (point 7); similarly, eligibility rules do matter, since they exactly define the moment (or period of life) in which the problem of whether going on working comes into play. Also other institutional settings (point 5) play a crucial role in making retirement choice "unique": for example, the possibility of switching from a full-time into a part-time job may suggest one model retirement as a "process" rather than as a mere discrete choice; finally, the severance payment often associated to the choice of retirement, the presence of other Social Security facilities (health care provision conditioned on being a pensioner), may contribute to amplify the difference between the two approaches.

Concluding, the different nature and same complexity of the mentioned scenarios makes it sensible to handle retirement independently; only to the extent a researcher is akin of the peculiarities of retirement, will he/she be able to decide properly which model better fits the situation under investigation.

In the light of this my classification criterion is the following: I ordinate the main estimation models according to their ability to addressing the points mentioned above. Again, I will also discuss those cases in which the border-line between categories appears more ambiguous.

Introductorily, it is perhaps worth recalling that retirement choices have been studied both from a "static" and a "dynamic" point of view. Very shortly, the former implies that individuals either have not to bother about the future, since the solution to their (possibly life-cycle) choice problem (i.e. intertemporal allocation between consumption and leisure) relies on current period variables only, or, if they do discount the future, they do not face uncertainty. The dynamic standpoint, on the contrary, by reckoning that retirement choice has a dynamic nature, implies that in each period of life individuals have to solve a maximization problem by assessing variables which will occur only in the future and are, in general, uncertain. Finally, the latter approach relies on the evidence that retirement is typically a discrete choice and very often, an absorbing state. Summarizing, retirement is a sequential choice implying forward looking behavior in an incomplete-information environment. In this section I present the main features of such approaches, starting with the static models[1].

[1] Other useful and extended overviews on retirement literature are Lazear (1986) and, more recently, Lumsdaine and Mitchell (1999).

2.1. The "static" model approach

In the first applied works explicitly dealing with this issue, retirement was modeled by adopting static theoretical models of labor supply, whereby the event of retiring was simply a special case (i.e. hours supplied or worked equal to zero). Feldstein (1974), Boskin and Hurd (1978) and Burtless and Hausman (1980) all make use of the one-period, under certainty, labor supply model to examine the role of Social Security in retirement choices.

More sophisticated works tried to estimate structural equations handling the life-time dimension of the optimization problem. In particular, these authors estimated equations representing the solution of the life cycle labor supply problem. Such approach selects either yearly or the whole life time labor supply (or, equivalently, the age of retirement) as the dependent variables of the equations (see, for example, Burbidge and Robb (1980) Gustman and Steinmeier (1986a)[2] and Burtless (1986), respectively).

Following Burtless (1986), the static model approach can be represented through the following linear equation:

$$R = \alpha X + \beta Z + \varepsilon \qquad [1]$$

where R is the retirement age, α and β vectors of parameters to be estimated, X a set of observed variables including personal characteristics affecting retirement, such as health status or marital status and Z parameters of the life-time budget constraint; finally, ε is a suitably distributed error[3].

A very similar approach is used by Hurd (1990) in his work on retirement decisions in a family contest: he estimates a structural model in which the utility function arguments are consumption of goods and number of retirement years (of both husbands and wives).

Despite their fascinating feature, such models suffer from several drawbacks: firstly, they do not take into account the fact that retirement is related to a lot of important institutional features (such as mandatory retirement, eligibility rules) which do not pertain to the ordinary labor supply decisions. Secondly, the linear approach is unsatisfactory in that it fails in capturing the discrete nature of retirement choice (which, very often, means entering an "absorbing state"); thirdly, both the one-period and the life-cycle models are unable to handle uncertainty, which makes them inappropriate, for example, for analyzing short run labor supply responses to unanticipated changes in retirement incentives. Incidentally, it is worth noting that dealing with complete life-cycle solutions for labor supply paths means imputing the compensation path of individuals over the entire life-cycle, a characteristic which is common to the dynamic approach.

2.2 Multinominal Probit and Logit models

An alternative method in the static approach is the *probit* or *logit* analysis. These models share the characteristic of treating the participation to the labor force as a discrete choice among a set of alternatives (such as full time, part-time job). I present the case of a multivariate (three alternatives) version, but the example can be readily generalized to more or less than three choices.

[2] As the authors point out, dealing with the life-cycle path has two drawbacks: the need of imputing the compensation path of individuals over the entire life-cycle and the absence of uncertainty.

[3] I do not enter into details about the estimation strategy, which accounts for non-linearities in the budget constraint and performs a maximum-likelihood estimation for the relevant parameters.

Suppose an individual face a three-way choice: retiring (1), working part-time (2) or working full-time. For each individual, define three random utilities corresponding to each choice:

$$U_i = u_i(X, \beta) + \varepsilon_i, \; i=1,2,3 \qquad [2]$$

where u( ) is the deterministic part of the function depending on X, unobserved vector of exogenous variables and β, a vector of corresponding coefficients to be estimated, and ε_i a random shock to utility representing imperfect perception and optimization by the individual and/or the inability of the econometrician to measure exactly all the relevant variables. Finally, suppose Ω to be the covariance matrix of the errors.

In fact U_i is unobservable and what is observed is y_i, which is a dummy variable such as:

$y_i = 1$ if $U_i > U_j$, $\forall j \neq i$.

$y_i = 0$ otherwise.

In other words, we do not observe the utilities, but only the individual's choice, that is the case in which one utility exceeds the others.

Therefore, the probability that the first alternative is chosen is given by:

$$P(y_1 = 1) = P(U_1 > U_i, \forall i \neq 1) = P(\varepsilon_i < \varepsilon_1 + u_1 - u_i, \forall i \neq 1). \qquad [3]$$

Now, if the errors ε_i's are independently and identically distributed according to the Type I extreme value distribution in standard form (also know as a Weibull or Gumbel distribution, with cumulative density function F(ε)=exp(-exp(-ε))), in the multinomial logit model the probability in equation [3] will have the analytic form:

$$P(y_1 = 1) = \frac{e^{u_1}}{\sum_{i=1}^{3} e^{u_i}}. \qquad [4]$$

Finally, by assuming that $U_i = \beta' X + \varepsilon_i$, one gets:

$$P(y_1 = 1) = \frac{e^{\beta' X_1}}{\sum_{i=1}^{3} e^{\beta' X_i}}. \qquad [4']$$

While the multinomial logit is popular in the literature, it suffers from the well-known property of independence from irrelevant alternatives (IIA), that is, the odds ratio for the *i*th and *j*th is *exp(u$_i$)/ exp(u$_j$),* which does not depend on the total number of choices considered. Since this assumption does not fit many real situations, an alternative model is the *multinomial probit.* This model assumes that the ε_i are jointly normally distributed with mean vector zero and covariance matrix Ω.

Since only differences in utilities can be considered, I define:

$$V_{i1} = U_i - U_1 = u_i - u_1 + \varepsilon_i - \varepsilon_1 = u_i - u_1 + v_{i1} \quad \forall i \neq 1. \qquad [5]$$

so that the outcome conditions may be rewritten as:

$y_i = 1$ if $V_i^* < 0 \ \ \forall i \neq 1$
$y_i = 0$ otherwise.

Therefore, one may write the probability that the first alternative is chosen:

$$P(y_1 = 1) = P(U_1 > U_i, \forall i \neq 1) = P(V_{i1} < 0, \forall i \neq 1) = P(v_{i1} < u_1 - u_i, \forall i \neq 1). \quad [6]$$

Since v_{21} and v_{31} have a bivariate normal distribution with mean vector zero and covariance matrix Ω_1 where the generic element $\omega_{kl1} = E(\varepsilon_k - \varepsilon_1)(\varepsilon_l - \varepsilon_1) = \omega_{kl} - \omega_{k1} - \omega_{l1} + \omega_{11}$ for each element ω_{kl1} of Ω_1, then the probability that alternative one will be chosen is given by:

$$P(y_1 = 1) = \int_{-\infty}^{u_1 - u_2} f(v_{21}, v_{31}) dv_{21} dv_{31} \quad [7]$$

where *f( )* has a bivariate normal distribution with mean vector zero and covariance matrix Ω_1.

On the other hand, as the choice set grows inference requiring exact evaluation of such integrals rapidly becomes infeasible. A few applications, in particular for the probit model, have tried to overcome this issue by performing (quasi) Monte-Carlo simulations and numerical integration of the choice probabilities and by substituting these simulated probabilities into likelihood functions or moment conditions[4]. Finally, several authors have set-up logit/probit models that account for forward looking behavior, that is the assessment of the retirement choice "value" at alternative ages in the future and/or the updating of such information as individuals age. This has been accomplished for, respectively, by both specific forward looking variables in the X vector (i.e. the Option Value, the pension accrual and the marginal cost of retirement)[5] and by using panel data, by which any agent's choice can be observed over a time interval. In particular, some authors have used either pooled cross-sections of yearly data or panel data to carry out such estimations. However, the adoption of the former approach raises no problem if observations in different cross-sections are mutually independent. If this conditions does not hold (for example, because one is dealing with panel data) the choice of pooling them for estimation is unsatisfactory, also accounting for some "correlation" between observations over time (for example, using "fixed effects" or auto-correlation of errors): in fact, in this case estimates are properly carried out only by recalling that retirement is a sequential choice, so that the probability of observing a state *i* at a certain date *t* for an individual, depends on the sequence of choices made in the past periods (*t-1*, *t-2* and so on)[6]. In fact such situation is better handled by using Survival Analysis or, more generally, dynamic models.

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[4] For an extensive survey on simulation methods and integration problems used in economics see Geweke (1995) and, more recently, Sandor (2001).

[5] See, for example, Lumsdaine and al. (1995) Coile and Gruber (2000) and, for Italy, Brugiavini and Peracchi (2001) and Mastrobuoni (2000). See also the empirical application at the end of the present work for the explanation of the Social Security incentive measures which can be used in reduced form estimations.

[6] Furthermore, using cross sections instead of panel data does not allow to take into account properly unobservable heterogeneity, which usually leads to biased estimations. On this point see Coile and Gruber (2000), Chan and Stevens (2001) and Spataro (2002b).

2.3. The Dynamic approaches

2.3.1 Survival analysis

The seminal applications of Survival Analysis (or Duration models) to retirement were carried out by Diamond and Hausman (1984) and Hausman and Wise (1985): both works relied on a version of hazard models, first applied in economics to the problem of measuring the duration of an unemployment spell. (see Lancaster (1979)).

In short, the major characteristics of the duration analysis are that 1) the dependent variable is the "waiting-time" until the occurrence of a well-defined event: in our specific case, "time-to-retirement" is taken as a (positive) random variable, either continuous or discrete; 2) observations are censored, that is for some individuals the event of interest has not occurred at the time the data are analyzed and 3) there are predictors or explanatory variables which affect the waiting time and, typically, time varying covariates can be accounted for Moreover, the distribution of the random variable can be fully parametric, semi-parametric or non-parametric and also time-gaps in observations can be easily tackled. Finally, also forward looking behavior can be taken into account.

Notice that this approach is particularly suitable when retirement is an absorbing state, that is, an irreversible decision which can be analyzed through epidemiology methods of studying the risk of diseases occurrence (such as death).

To introduce the model, let us assume for the moment that T is a continuous random variable with probability density function *f(t)* and cumulative distribution function $F(t) = P(T \le t)$, giving the probability that the event has occurred by duration *t*. Similarly, the complement of F, the survival function, can be defined as:

$$S(t) = P(T > t) = 1 - F(t) = \int_t^{\infty} f(x)dx \qquad [8]$$

which gives the probability of being "alive" at duration *t*.

Then, by defining the hazard function as:

$$\lambda(t) = \lim_{\Delta \to 0} \frac{P(t < T \le t + \Delta \mid T > t)}{\Delta} \qquad [9]$$

which expresses the instantaneous rate of occurrence of the event[7], one can easily verify that

$$\lambda(t) = \frac{f(t)}{S(t)}. \qquad [10]$$

In other words, the hazard at duration *t* equals the ratio between the density of event at *t* and the probability of surviving to that duration without experiencing the event.

Finally, from expression [7], the following relationships hold:

$$\lambda(t) = -\frac{d}{d(t)} \log S(t), \qquad [11]$$

[7] Precisely, the numerator is the conditional probability of the event occurrence by duration interval $(t, t + \Delta)$ given that it has not occurred before. The ratio to the interval width gives the rate of occurrence per unit of time, and, finally, by taking the limit we get the instantaneous rate of occurrence.

and, consequently,

$$S(t) = \exp\left(-\int_0^t \lambda(x)dx \right) \qquad [12]$$

These results show that the distribution of T can be characterized equivalently both in terms of the survival and the hazard function.

Now, suppose there are individuals i = 1,...,N, each of them entering a state (e.g. employment) at time t = 0 and that at a certain point in time some of them retire and some continue to work (that is, some of them exit the spell while others are censored): if censoring is non-informative[8], one can write the likelihood function for this sample as:

$$L = \prod_i^N L_i = \prod_i^N \lambda(t_i)^{d_i} S(t), \qquad [13]$$

where d_i is an indicator variable taking on value 1 if individual i retires at duration t_i and zero otherwise.

Taking logs and recalling expression [12] one obtains:

$$\log L = \sum_{i=1}^N \left[d_i \log \lambda_i - \int_0^t \lambda(x)dx \right] = \sum_{i=1}^N \left[d_i \log \lambda_i - \Lambda(t_i) \right], \qquad [14]$$

where $\Lambda(t)$ is defined as the cumulative hazard (or cumulative risk).

Usually, econometricians are interested in the effect that any variables may have on the probability of retiring. For this reason one typical estimation strategy is to express either the (logs of) duration as a function of (observed) covariates X_{it} and (unobserved) parameters $\beta(t)$ which may vary or not over time.

For example, an usual specification, since duration must be positive, is:

$$\log T_i = X_i'\beta + \varepsilon_i, \qquad [15]$$

with ε_i a suitably chosen error term, so that

$$T_i = \exp(X_i'\beta + \varepsilon_i). \qquad [16]$$

Now, different kinds of parametric models can be obtained by assuming certain distributions for the error term[9], whose parameters are all estimable by maximizing the log-likelihood for censored data described above.

However, since economic theory does not necessarily produces these functional forms, researchers prefer not to impose too much structure to the (unknown) duration function.

In the light of this, reduced forms are adopted, by specifying directly the hazard function. The most popular is the Box-Cox proportional hazard model of the form:

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[8] This means that the censoring of an observation should not provide any information regarding the prospects of survival of that particular unit beyond the censoring time.

[9] We can obtain, for example, the Tobit model or the exponential regression model.

$$\lambda(t \mid X_{it}) = \lambda_0(t)\exp\left(X_{it}{'}\beta_t\right), \quad [17]$$

where $\lambda_0(t)$ is the baseline-hazard which describes the risk for individuals with $X_{it}=0$ and serves as a reference cell, while the second term is the relative risk, that is a proportionate[10] increase or reduction in risk associated to the set of characteristics X_{it}.

Again, a lot of specifications are possible according to the hypothesis on the form of the baseline-hazard: parametric (i.e. exponential, Weibull, gamma and generalized F distributions), semi-parametric, with mild assumptions on $\lambda_0(t)$, and non parametric, which leaves the baseline-hazard completely unspecified[11].

Till now I have supposed that observation time is continuous. However, the extension to the discrete time is straightforward[12].

The model can be presented as follows. Let us define the *hazard at duration t for individual i ($\lambda_i(t)$), as the conditional probability of retiring at that "time"*[13]*, given that he has survived (at work) through that point:*

$$\lambda_i(t) \equiv \lambda_{it} \equiv \Pr(T = t \mid T \geq t; X_{it}), \quad [18]$$

where *T=(1,2…)* is a discrete time variable *(duration)* with unspecified probability *f(t)=Pr(T=t)* and X_{it} a set of covariates varying over time and across individuals *(i)*. If one then defines the survival function S_{it} as the probability that for individual *i* survival time *T* is at least *t*, so that:

$$S_i(t) = S_{it} = \Pr(T \geq t; X_{it}) = \sum_{z=t}^{\infty} f_{iz}, \quad [19]$$

it can be shown that the following property holds:

$$S_{it} = \Pr(T > t) = \prod_{z=1}^{t-1}(1-\lambda_{iz}), \quad [19']$$

and, consequently, the unconditional probability of retiring in period *t is:*

$$\Pr(T = t) = \lambda_{it}S_{it} = \lambda_{it} \cdot \prod_{z=1}^{t-1}(1-\lambda_{iz})^{14}. \quad [20]$$

Thus, the Likelihood function of the sample can be written as:

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[10] Precisely, the increase or reduction in risk is the same (or proportional) at all durations t if the parameter vector does not change over duration. The model presented here is a generalization of the proportional hazard model.

[11] This approach relies on a partial likelihood function proposed by Cox (1972) in his original paper. See also Kalfleisch and Prentice (1980), cap. 2, for an extensive presentation of the possible specifications.

[12] Such extension is particularly suitable when data are grouped into time-intervals. For an exhaustive explanation of such extension see Jenkins (1995).

[13] For simplicity one can think of time as to be equivalent to "duration", although calendar time does not coincide with duration time necessarily.

[14] Actually, the same property applies in case of "delayed entry", in that individuals enter the observation set, say, in with duration r>1; in this case the new formulation of [3] would be:

$\Pr(T = t \mid T > r-1) = \lambda_{t} \cdot \prod_{z=r}^{t-1}(1-\lambda_{z})$. The underlying assumption here is that hazard rates are not dependent on duration and that censoring is non-informative (see Jenkins (1995), p. 133).

$$L=\prod_{i=1}^{n}\cdot\left[\lambda_{it}\cdot\prod_{z=1}^{\tau_i-1}(1-\lambda_{iz})\right]^{\eta_{it}}\cdot\left[\prod_{z=1}^{\tau_i}\cdot(1-\lambda_{iz})\right]^{1-\eta_{it}}, \qquad [21]$$

where $i=1\ldots n$ is the number of individuals observed in the whole sample, τ_i the last period of duration (or observation) for agent i, $\eta_{it}=1$ if by duration t individual i retires and 0 otherwise. Finally, after some manipulation, and expressing again the hazards as functions of the set of covariates X_{ji}, the equation above can be expressed in logarithmic terms:

$$LogL=\sum_{i=1}^{n}\sum_{z=1}^{\tau_i}\ \{[\eta_{iz}\log\lambda_{iz}(X_{iz})]+[(1-\eta_{iz})\log(1-\lambda_{iz}(X_{iz}))]\}. \qquad [22]$$

By this formulation, the η can be interpreted as an independent Bernoulli observation with probability given by the hazard λ for individual i at duration t.

Again, the specific formulation that applies to any model depends on the particular function assigned to the hazards (parametric, piece-wise constant, non parametric with logit, log-log link etc).

Concluding, it can be said that Duration models are quite useful in that they can unveil the agent's decision rules and test the significance of a number of variables in the decision process. Moreover, they are particularly flexible and can face lots of estimation difficulties (like time gaps or censoring in the data). On the other hand, as reduced-form estimation methods they suffer from the limit of being independent of any particular behavioral theory. In particular, as far as retirement is concerned, the role played by "forward looking" variables can only be captured indirectly, in that none of such models can mimic the way in which Social Security accruals influence the underlying "maximizing" behavior of workers. Also uncertainty affecting the future (like income, health status and so forth) is not suitably modeled. In fact, current decisions would depend on the complete joint distribution of shocks affecting all future events and outcomes. For this reason researchers have been exploring alterative approaches, known as *structural models*, which descend more directly from economic theory.

2.4. Structural models

Here I present two frameworks: the *Option Value* and the Dynamic Programming. Both models share the characteristic of modeling individual choices by assuming that forward looking agents maximize a "utility" or "value" function in presence of uncertainty affecting future events: in other words, the choice of retirement is the solution to a maximization problem. In this framework estimated parameters have an intuitive economic meaning and, thus, can be easily interpreted.

On the other hand, the cost of such an approach is the complication of computations and, often, the strong specification dependence of estimates.

2.4.1. The Option Value model

The *Option Value* model (OVM) was originally set up by Stock and Wise (1990). In order to introduce the structure of such framework, let us suppose an individual (h) is assessing the decision of retiring in the current year (s): according to the OVM, the individual will compare the value of retiring in that year with the (maximum) value of retiring in any of the subsequent years. The difference between these two values is called the *Option Value* of postponing retirement.

The decision rule is straightforward: if the *Option Value* is positive, the individual will go on working, if negative, he/she will retire.

Precisely, agents are supposed identical as for the preferences and are assigned an intertemporal indirect utility function (or Value function) $V_{s,h}(r)$ of the form:

$$V_{s,h}(r) = \sum_{t=s}^{r-1} \gamma^{t-s} U(W_{t,h}) + \sum_{t=r}^{D} \gamma^{t-s} U(B_{t,h}(r)), \qquad [23]$$

where r is retirement year, D is the year of death, W e $B(r)$ are, respectively, the real wage and the real pension benefit and γ the individual intertemporal discount rate.

Then, let us assume the instantaneous indirect utility function be as follows:

$$U_{t,h} = W_{t,h}^{\alpha} + \vartheta_{t,h} \qquad [24a]$$

$$U_{t,h} = (\theta B_{t,h}(r))^{\alpha} + \varsigma_{t,h} \qquad [24b]$$

where $\vartheta_{t,h}$ and $\varsigma_{t,h}$ are individual-specific independent disturbances, representing, for example, maximization mistakes, incomplete information, health or job-related shocks.

Therefore, the value function can be rewritten as:

$$V_{s,h}(r) = E_{s,h}\left(\sum_{t=s}^{r-1} \gamma^{t-s} U(W_{t,h}) + \vartheta_{t,h} \right) + E_{s,h}\left(\sum_{t=r}^{D} \gamma^{t-s} U(B_{t,h}(r)) + \varsigma_{t,h} \right), \qquad [25]$$

where $E_{s,h}$ is the expectation operator for individual h in year s.

Now, if the individual is assessing whether to retire in year s or in $s+1$, retirement year will be the former if and only if $V_{s,h}(s) > V_{s,h}(s+1)$.

However, calling R the sequence of years after s in which, according to the current rules, it is possible for him/her to retire, agent h will compare the "value of retiring" in year s with *the value of all the years belonging to R.* Consequently , the complete correct decision rule is:

retire in year s iff

$V_{s,h}(s) > V_{s,h}(r) \qquad \forall r \in R$,

That is

$O_{s,h}(r_s^*) \equiv V_{s,h}(r_s^*) - V_{s,h}(s) < 0$,

with $O_{s,h}(r_s^*)$ the *Option Value*, r_s^* *argmax* $V_{s,h}(r)$ from year s standpoint.

Expanding the expression of the OV according to the notation used in equation [25] one gets

$$O_{s,h}\left(r_s^*\right)=E_{s,h}\left(\sum_{t=s}^{r_s^*-1}\gamma^{t-s}\left(W_{t,h}^{\alpha}+\vartheta_{t,h}\right)\right)+E_{s,h}\left(\sum_{t=r_s^*}^{D}\gamma^{t-s}\left(\left(\theta B_{t,h}\left(r_s^*\right)\right)^{\alpha}+\varsigma_{t,h}\right)\right)+$$
$$-E_{s,h}\left(\sum_{t=s}^{D}\gamma^{t-s}\left(\left(\theta B_{t,h}(s)\right)^{\alpha}+\varsigma_{t,h}\right)\right). \qquad [26]$$

Now, supposing that the survival probabilities are independent of the earning streams and of the disturbances, after some calculus, one can write

$$O_{s,h}\left(r_s^*\right)=\left(\sum_{t=s}^{r_s^*-1}\pi(t\mid s)E_{s,h}\gamma^{t-s}\left(W_{t,h}^{\alpha}-\left(\theta B_{t,h}(s)\right)^{\alpha}\right)\right)+$$
$$+\left(\sum_{t=r_s^*}^{D}\pi(t\mid s)\gamma^{t-s}E_{s,h}\left(\left(\theta B_{t,h}\left(r_s^*\right)\right)^{\alpha}-\left(\theta B_{t,h}(s)\right)^{\alpha}\right)\right)+\left(\sum_{t=s}^{r_s^*-1}\pi(t\mid s)E_{s,h}\gamma^{t-s}\left(\vartheta_{t,h}-\varsigma_{t,h}\right)\right), \qquad [27]$$

with $\pi_{t,s}$ being the probability of surviving in year *t* conditionally on being alive in year *s*. Finally, the model poses some hypotheses on the random process originating the disturbances; precisely, it is assumed that the errors follow a Markov chain such that:

$$\varsigma_{t,h}=\phi\varsigma_{t-1,h}+\xi_{h\varsigma} \qquad [28a]$$

and

$$\vartheta_{t,h}=\phi\vartheta_{t-1,h}+\xi_{h\vartheta}, \qquad [28b]$$

with $E_{t-1}\left(\xi_{h\varsigma}\right), E_t\left(\xi_{h\vartheta}\right)=0$, for *t=s+1,...,D*. Defining $\omega_{t,h}=\vartheta_{t,h}-\varsigma_{t,h}$ and exploiting the fact that $E_{s,h}\left(\omega_{t,h}\right)=\phi^{t-s}\omega_{s,h}$, then the expression [27] can be written as:

$$O_{s,h}\left(r_s^*\right)=m_{s,h}\left(r_s^*\right)+e_{s,h}\left(r_s^*\right)\omega_{s,h}, \qquad [29]$$

where

$$m_{s,h}\left(r_s^*\right)=\left(\sum_{t=s}^{r_s^*-1}\pi(t\mid s)E_{s,h}\gamma^{t-s}\left(W_{t,h}^{\alpha}-\left(\theta B_{t,h}(s)\right)^{\alpha}\right)\right)+$$
$$+\left(\sum_{t=r_s^*}^{D}\pi(t\mid s)\gamma^{t-s}E_{s,h}\left(\left(\theta B_{t,h}\left(r_s^*\right)\right)^{\alpha}-\left(\theta B_{t,h}(s)\right)^{\alpha}\right)\right) \qquad [30]$$

and

$$e_{s,h}\left(r_s^*\right)=\sum_{t=s}^{r_s^*-1}\pi(t\mid s)(\gamma\phi)^{t-s}. \qquad [31]$$

I can now write the probability that an individual retires in year *s* as the probability that the

OV is negative. Thus, using expression [27] and manipulating it opportunely, one obtains

$$P(r=s)=P\left(-\frac{m_{s,h}(r)}{e_{s,h}(r)}>\omega_{s,h}\right)=F\left(-\frac{m_{s,h}(r)}{e_{s,h}(r)}\right) \qquad \forall r\in R, \qquad [32]$$

with F the normal cumulative probability.

Equivalently, the expression above can be written as:

$$P(r=s)=F\left(-\frac{m_{s,h}(r_s^{\circ})}{e_{s,h}(r_s^{\circ})}\right), \qquad [33]$$

where r_s° is *argmax* $O_{s,h}(r_s^{*})$ $\forall r\in R$ [15]. The event of retiring in year s is thus a random variable which, under the hypotheses I have posed, has mean zero and variance σ_w. Obviously, the probability of continuing to work is the complement to one of $P(r=s)$.

Till now I have considered the decision rules of retiring in one year only. However, if one allows for the possibility to follow an individual's behavior for two subsequent years, the model can, on the one hand, better account for the dynamic nature of the choice; on the other hand, it becomes more complicated since it involves the specification of a multinomial choice model. In particular, as the covariance between the variables is assumed to be non-zero, only the multinomial probit model can be used[16].

More precisely, three are the possible outcomes: retiring in the first year, in the second year or continuing to work. For example, in year $s+1$ (the second year), the probability of retiring is given by:

$$P(r=s+1)=P\left(O_{s,h}(r_s^{\circ})>0,O_{s+1,h}(r_{s+1}^{\circ})<0\right)=$$

$$P\left(-\frac{m_{s,h}(r_s^{\circ})}{e_{s,h}(r_s^{\circ})}<\omega_{s,h},-\frac{m_{s,+1h}(r_{s+1}^{\circ})}{e_{s+1,h}(r_{s+1}^{\circ})}>\omega_{s+1,h}\right). \qquad [34]$$

Consequently, the probabilities of retiring in two subsequent years are given by the appropriate integrals over a bivariate normal function $\Phi(\omega_{s,h}\omega_{s+1,h};\Sigma)$ with:

$\omega_{s,h}$ $\quad i.i.d.$ $(0,\sigma_{\omega})$

$\omega_{s+1,h}$ $\quad i.i.d.$ $(0,\phi^2\sigma_{\omega}+\sigma_{\xi})$

and

$$\Sigma=\begin{bmatrix}\sigma_{\omega} & \phi\sigma_{\omega}\\ & \phi^2\sigma_{\omega}+\sigma_{\xi}\end{bmatrix}$$

the variance-covariance matrix.

For example, using the standardized variables, the probability of retiring in year $s+1$ is:

[15] The subscript of r° means that r is the optimum from year s point of view. Notice that r_s° is an estimator of r_s^{*}.

[16] In fact, the multinomial logit model is based on the assumption of the independence of the irrelevant options, which implies the covariance matrix being diagonal. See Greene (1999), chapter 19.

$$P(r = s+1) = \int\limits_{-\frac{\frac{m_{s+1,h}\left(r_{s+1}^{\circ}\right)}{e_{s+1,h}\left(r_{s+1}^{\circ}\right)}}{\sqrt{\phi^2\sigma_\omega+\sigma_\xi}}}^{+\infty} \int\limits_{-\infty}^{-\frac{\frac{m_{s,h}\left(r_s^{\circ}\right)}{e_{s,h}\left(r_s^{\circ}\right)}}{\sqrt{\sigma_\omega}}} \Phi\left(\omega_{s,h}^{*}, \omega_{s+1,h}^{*}; \lambda_1\right) d\omega_{s,h}^{*}\, d\omega_{s+1,h}^{*}\ , \qquad [35]$$

with $\omega_{s,h}^{*}$ e $\omega_{s+1,h}^{*}$ normal standard variables, λ_1 the correlation coefficient and Φ the bivariate normal distribution. The probabilities of the other outcomes can be derived analogously.

A final comment on the OV model: notice that within this framework the decision to retire is taken according to *the maximum expected value of future utility levels,* while, typically, a stopping-rule framework would imply the assessment of *the expected maximum value.* As a consequence, the OV model will tend to understate the value of postponing retirement[17]. However, the relevance of the error implied by such approximation is not univocal.

2.4.2 Dynamic programming

The "Dynamic programming" approach assumes that agents' behavior is the output of an "optimal decision rule" or the solution of a controlled discrete stochastic process[18].

Precisely, the sequence of decisions, taken under uncertainty, can be represented through a stochastic decision process; individuals are supposed to be rational and maximize a life-time utility function of the form: $E\left\{\sum_{t=0}^{T} \beta^t u(d_t, s_t) \mid s_0 = s\right\}$ where E is the expectation operator, $u(\ )$ is the instantaneous utility function, d and s sets of control and state variables respectively, $\beta \in (0,1)$ is the intertemporal discount rate. The problem can be solved by finding an optimal decision rule $d_t = \theta(s_t)$ that is solution to:

$$V_0^T(s) \equiv \max E_\theta \left\{\sum_{t=0}^{T} \beta^t u(d_t, s_t) \mid s_0 = s\right\},$$

where E_θ is expectation with respect to the controlled stochastic process (d_t, s_t). The sources of uncertainty are on one hand, uncertain future states (such as health status, mortality, employment) on whose transitions agents have subjective (Markovian) transition probabilities $p(s_{t+1} \mid s_t, d_t)$; on the other hand, there are unexpected shocks (ε_t)[19] occurring in each decision period and, typically, affecting the utility function.

In particular ,since in retirement decisions d is a discrete variable, the problem has a discrete decision process nature. Consequently, the optimal decision rule is determined by a system of inequalities rather than as a solution to a (Euler) first order condition. Besides that, since closed forms of θ are rarely available, most structural estimation methods for these kind

[17] For example, Lumsdaine, Stock and Wise (1991) show that their strategy has the same predictive power as the exact solution and, in any case, is much better that a model ignoring dynamics completely. On the contrary, Stern (1996) points out that the approximation above performs well only in limited situations, while, the correct "expected maximum value" rule is satisfactory even when error distributions are misspecified.

[18] In this session I draw from Rust's (1994) line of exposition. Another model was developed by Gustman and Steinmeier (1986b).

[19] Usually, these shocks are interpreted as state variables unobservable to the econometrician.

of models requires estimation of θ via numerical methods (although other techniques rely on Monte Carlo simulations of the controlled stochastic process $\{s_t, d_t\}$).

A simplified version of the problem assumes that: ε_t enters u in an additive separable fashion and is an IID extreme value variable; p satisfies a conditional independence condition: under such assumptions a dynamic generalization of the multinomial logit model can be obtained, whereby the conditional choice probabilities $P(d_t \mid x_t, \vartheta)$ (with ϑ the vector of parameters of p and u to be estimated):

$$P(d_t \mid x_t, \vartheta) = \frac{e^{[v_\vartheta(x_t, d_t)]}}{\sum_{\bar{d} \in D(x_t)} e^{[v_\vartheta(x_t, \bar{d})]}} \quad [36]$$

where x is the non-stochastic partition of variables in s observed by the econometrician . The relevant difference with the static logit model is that there v is a one period utility function, linear in parameters ϑ, while in this contest v is the sum of all the expected discounted utilities in the (present and) future periods[20]. Some works have relaxed the hypotheses I have presented above, by allowing the error terms enter u in a nonlinear, non-additive fashion and be serially correlated (see Hotz et al (1993)). Moreover, researchers would like to extend the level of realism of the models by introducing new variables (i.e. savings or the family dimension) and relaxing assumptions (i.e. rational expectations). However, it is worth recalling that typically in these models the "curse of dimensionality" problem (i.e. the exponential increase of the burden in terms of time/space needed to solve the problem) dramatically affects the level of realism or detail which can be achieved. Furthermore, the more complicate the model is, the heavier its dependence on the specification adopted. As pointed out by Wolpin (1996), to deal with this issues researchers may intervene over a number of dimensions: 1) the size of the choice set, 2) the size of the state space, 3) the functional form of the utility function and the (joint) distribution of unobservables[21]. Another problem is that, despite a number of sufficiently detailed utility-based optimizing models can be calibrated to observable economic variables, they may generate very different predictions about the effects of policy changes on macroeconomic variables. For example, Engen, Gravelle and Smetters (1997), evaluate the effects of fundamental tax reform by calibrating several different models and sets of model parameters –such as deterministic OLG, stochastic OLG, infinite horizons, each with several parameter set choices- to the same initial economy. In fact they obtain very different predictions according to the specification adopted[22].

All this considered, I conclude with the argument made by Wolpin (1996): especially for policy analysis, "*…informed judgments* [concerning which model to use] *should not be based on methodological predispositions, but on evidence of performance*". After all, a "fair pragmatism", that is the emphasis on either computational complexity (or theoretical coherence) or predictive power driven by the main scope of the researcher's work, is still a valid criterion of choice whenever the trade-off between the two dimensions occurs.

[20] Also the functional form of v is not known a priori, so its values have to be computed numerically for any particular value of ϑ

[21] See also the results in Rust (1997) which break, via random Monte Carlo integration methods, the curse of dimensionality for discrete decision processes.

[22] In this sense, one cannot discriminate between different choices for the utility function and parameters basing simply on how well the model is calibrated to the actual economy, but, rather, on its ability to replicate historical economic changes after a policy reform.

2.5. Other issues

A number of researchers are working to enrich retirement models, as both the demand for new applications and the set of theoretical and calculation tools at hand are growing rapidly.

As for the new applications, one of the most promising fields is dynamic microsimulation[23], whose development since early 1980's has been steady, especially due to the increasing need of information concerning retirement behavior and health related topics in ageing societies. In particular, the 1990's have witnessed important developments in the way in which transition probabilities of micro-units (i.e. from work into retirement, from unemployment into employment status) are calculated. For example, newer dynamic models are replacing annual transition probabilities with hazard models: the DYNAMOD-2 model uses survival functions to predict the time at which selected possible monthly changes of status will occur (Antcliff, 1993)[24]. Similarly, Bianchi and al. (2001) endogenize individual retirement choices by applying the *Option Value decision-rule* to their dynamic microsimulation model calibrated for Italy.

As for the new econometric models, a few challenging issues are currently on the researchers' agenda**,** all concerning the strengthening of models degree of realism; in particular, a major goal is to set-up a unified framework explaining the most relevant lifetime economic decisions of agents. For example, it is unlikely that individuals make retirement decisions independently of the decision of saving. This is particularly true in the late years of working careers, as workers become more aware of their future income needs and of the adequacy of existing saving. Till now almost no model has dealt simultaneously with saving and retirement, although there are many instances in which a feedback from saving to retirement (and vice versa) is present. Rust and Phelan (1997), for example, include uncertainty in their model and imperfect markets, but no saving decision. Stock and Wise (1990) assume that individuals consume all their income in every period.

Another issue is concerned with the effect of health insurance and private pensions; in fact, some empirical evidence suggests that retiree health insurance affects the timing of retirement by modifying both the budget constraint and preferences (see Rust and Phelan (1997), Johnson, and al. (2000); Gruber and Madrian (1995); Karoly and Rogowski (1994)). Also private pensions are also documented to be significant in the retirement decision (Madrian (1993) and Madrian and Beaulieu (1998)): as a consequence, health insurance and/or private pensions should be incorporated in a model of retirement.

Finally, another development is the extension of these models to analyze the joint decision making within families or couples about retirement. Intuitively, the primary motive for joint retirement decisions is the complementarity of leisure: for married individuals who wish to spend their leisure time together with her/his spouse, leisure time gives more satisfaction to one spouse as the leisure time of the other spouse increases. This may also be due to couples' desire to relocate to different regions of the country as they become older, which would be easier to accomplish if neither spouse were working. From another point of view, assortative mating may also lead a couple to have similar retirement patterns, in that spouses with similar preferences over combinations of leisure and consumption are likely to retire at similar ages. Finally, correlations in wages, Social Security benefits and pensions between husbands and wives can also lead to similar retirement decisions.

[23] See the works by Nelissen (1994) and Gupta and Kapur (2000) as interesting applications of microsimulation techniques.

[24] Other works applying the same strategy are Laditka (1996), Galler (1997) and Gribble (2000).

The existing applications of family decisions have adopted versions both of the "static" approach (see Hurd (1990), for Italy Colombino (2002)[25]) and dynamic. Among the latter, both survival models (see for example the work by An et al. (1999)) and structural models have been explored (see, for example, Gustman and Steninmeier (1994), Blau (1998); for Italy, see Mastrogiacomo (2001)). However, other applications are needed in order to shed light on the significance of couple coordination behavior in retirement decisions.

Finally, to my knowledge the work by Van der Klaauw and Wolpin (2001) is the very first attempt to estimate a structural model of joint savings and retirement decisions both by single and couples, and including public and private pensions and uncertainty of a host of future outcomes (like health status, survival and the generosity of the Social Security system).

All in all, the possibility of developing new applications and setting-up richer structural models is a fascinating challenge which has been already accepted by several authors; however, it worth recalling that such a strategy is not costless: as I have pointed out, the adoption of more realistic and detailed models, at the moment, poses major problems, such as highly computer-time consuming and specification dependent estimates and, the need of high quality datasets as well. As for the latter, the availability of suitable longitudinal or panel data is claimed to be still a problem for some countries (and, to some extent, also for Italy)[26].

3. Retirement in Italy

In this section I present, as an example, two applications to Italy concerning retirement choices. More precisely, I compare the performance of two dynamic models: Duration and *Option Value* models. Before showing the results, I briefly introduce some stylized facts and the main results and open questions raised by previous studies on Italy.

3.1. Institutional features of Social Security in Italy and some empirical facts

Before 1990s reforms the Italian Social Security was a mandatory, Pay-As-You-Go system providing two types of defined benefit pensions: the "old age pensions" and "seniority pensions" (see Table 1); the former could be claimed conditional on the achievement of age 60 and at least 15 years of Social Security tax payment. To the latter were entitled individuals who, no matter how old, had completed 35 years of contribution payment, or 20 years if working in the Public Sector. Eligibility rules were generous also for self-employed and even more favorable to women. The National Fund also provided a means-tested income maintenance scheme for individuals over 65 not covered by old-age insurance (*minimum benefit scheme or "Pensione sociale"*), and, among other non contributory provisions, survivor benefits and disability pensions. The system was (and is still) financed by both employers and employees contributions, with an overall payroll tax of about 26% of gross earnings up to 1992. Employees also contributed a further 7.41% to a "severance pay fund" called *TFR*, managed by the firm and yielding a legislated rate of return (1.5% plus ¾ of yearly inflation rate). As for retirement, it was not mandatory at the "normal age" (age 60), in that a worker could postpone retirement up to age 65 in order to complete (no more than) 40 years of contributions.

As far as the computation of benefits is concerned, the formula consisted in the product of three elements: the "interest yield" (or "yearly rate of return"), the number of contribution years paid to the Fund and the *pensionable wage*. The first parameter was 2% per year,

[25] However, the equations estimated in this work can be interpreted as closed-form (approximated) solutions of a dynamic optimization problem without uncertainty.

[26] On this point, see Spataro (2000a) and Brugiavini and Peracchi (2001)).

although lower rates were applied to the *pensionable earnings* in excess of a given limit and according to earning brackets. This reduction did not apply to Public Sector employees who enjoyed a slightly higher rate of return; as for the second element, the maximum amount of years considered for computation was 40, so that no more than 80% of *pensionable wages* were attainable at the moment of retirement. The *pensionable wage*, finally, was computed as an average of the last five pre-tax wages, corrected into real terms through the consumer price index. On the contrary, for Public employees only the last wage was relevant for the *pensionable earnings* computation: combined with other favorable rules, this led to the possibility of achieving at most a more than 90% replacement ratio. Finally, pensions were indexed proportionally to the nominal wages growth rate. As it will become clear in the analysis, the system typically provided more than actuarially fair pensions, since the latter were independent both of the amount of contributions paid while working and of life expectancy. This feature and the almost continuous changes operated by the Parliaments towards increasing generosity led to the crisis of early 90's and to the corrections introduced by the year 1993, 1995 and subsequent reforms. In short, these reforms have tightened eligibility requirements, reduced the Social Security wealth (especially via the reduction of the benefit indexation), increased the payroll taxes up to about 33% for employees, moved the system towards a "contribution-defined" mechanism and initiated an harmonization process of the rules among the several National Funds (for example, caps for *pensionable earnings* and differentiation of the internal yield according to wage brackets were introduced also for Public Sector employees, Social Security payroll taxes for self-employed were progressively increased in order to reduce the gap with other categories). These measures, as it has been claimed by the same legislator and to same extent confirmed by some authors[27], should be able to stabilize the long-run ratio of pensions expenditure to GDP. In fact, the way the reforms have been phased in, so that actuarially fair computation mechanism and some minor changes do not even apply to some category of workers (according to seniority criteria) slackens the positive effects on the State unbalances so much that Italy will face a hump of Social Security expenditure-to-GDP ratio by the early 30's of the current century and the Social Security system will continue to experience unbalances by some percentage point of the GDP[28].

These worrying forecasts are also due, and possibly worsened, by the consequences of:

- the demographic crisis that, affecting the majority of western economies, is particularly dramatic in Italy, accelerating the ageing process of the population and, consequently, causing the worsening of the dependency ratio;
- the persisting high unemployment rates (mostly affecting younger cohorts) and low labour force participation rates (especially for women and for the elder cohorts);
- the poor growth path of the economy, also due to the tightening policies implemented to fulfill the requirements of the European Monetary Union;

[27] Precisely, Bosi (1995 and 1997) has shown that this will be true, at the steady state, if the GDP growth rate will at least equal the discount rate used in the pension formula (i.e. 1.5%). For critical reviews of recent Italian reforms see Castellino (1994 and 1995), Gronchi (1995), Peracchi and Rossi (1996), Onofri (1998) and Vitaletti (2000). For the main macroeconomic features of the reforms see Bosi (1995 and 1997), while the works by Ferraresi and Fornero (2000) and Spataro (2000b) shed light on short run and long-run early retirement incentives, respectively.

[28] These features have given raise to many criticisms, which cannot be reported here exhaustively. Summarizing, besides the excessive length of the transition phase, which will maintain significant early retirement incentives and wealth windfall gains for the baby boomers cohorts, the other major criticisms concern the regime phase: the lack of economic growth indexation of benefits, the excessive level of the contribution rates, which would impede the possibility of a real diversification; the difference between the actual and the computation payroll-tax and, finally, the permanence of several National Funds and differences in the pension rules among sectors. Finally, as for the forecasts of the Social Security unbalances, see Castellino e Fornero (2001) and Commissione ministeriale (2001).

- the low accumulation rates, as a result of the poor role played by private pension funds[29].

Finally, such concern has been also boosted by the ambitious economic objectives that Italy has recently undertaken, together with EU partners, at the "Lisbon 2000 meeting" (and recently restated by the Stockholm and Laeken Meetings held in year 2001), which imply *a stable 3% economic growth rate, the sustainability of Social Security systems and an overall 70% activity rate (60% for female workers) by 2010.*

In the light of these arguments, calls for new corrections of such distortions are raised and an increasing number of studies dealing with these issues have being carried out.

I next turn to present some "stylized facts" concerning retirement in Italy. For this purpose I present the Figures 1-6 in the Appendix related to the stock of retirees interviewed in 1995. Thus, looking at Figures 1 and 2, that two main persisting features in male employees retirement behavior may be recognized before the reform period (i.e. prior to year 1993): in fact, retirement mostly occurs *at age 60 and with 35 years of contribution payment.*

However, a deeper insight unveils a more complex scenario, in that Public Sector workers leave the labor force both at different ages (as the spikes at ages 55-60-65 depicted in Figure 3 show) and, on average, with lower contributions (see Figure 4); in fact, these characteristics are mainly due to different SS rules affecting each Sector, since State employees were generally subject to a more favorable legislation both on eligibility and on benefit computation grounds; however it also indicates a substantial heterogeneity that needs to be explained: in other words, it is worth verifying whether the variability of retirement choices between the two Sectors is statistically significant and, if this is the case, to what extent this stems from eligibility constraints or from different underlying preferences respectively.

Furthermore, by looking at Figures 3 and 5 it is possible to recognize the changes in the timing of retirement after the 1993-95 reforms, whereby the distributions of retirement ages become smoother and more dispersed: in fact, the modal value of frequencies in such years falls down and more spikes at lower ages occur: in particular, the spikes at age 56 and 59 in 1994, and at age 61 in year 1995 are noteworthy. Such changes are confirmed by the figures reported in Table 3, which are related to the sample used for estimations; on the one hand, the percentage of individuals that left the labor force in 1993 and 1995 decreased (with the exception of year 1994): however, this fact is likely to be the consequence of the already mentioned restrictions imposed to early retirement in those years; in fact, if we look at the pension-eligible individuals sub-sample, such percentages turn out to have increased dramatically: in fact more than 20% of the latter retired after 1993, against a mean of 14% of retirement flows for the whole period considered. Note that the relatively low exit rates from labor force occurred 1993 suggest that individuals have been "surprised" by the reform, so that only in the subsequent years they were able to react to the Government tightening policies.

3.2. Recent results on retirement in Italy

Results by applied woks on retirement in Italy are recent and, to some extent, still contradictory. In fact some works tend to support an optimistic judgment on recent reforms: Brugiavini (1999), for example, by analyzing early retirement incentives provided by the Italian legislation before the 1992 reform finds significant differences in work-force participation choices for individuals who have been differently affected by the reform: in

[29] On these point see, among others, Blondal and Scarpetta (1998), Rossi and Visco (1995) and more recently, Fornero (1999).

particular, retirement is postponed if pension wealth is lowered[30]. Similarly, in an applied paper Blondal and Scarpetta (1998) show that the low work force participation rate in Italy, if compared to the other OECD State members, can be explained by the generous incentives to early retirement[31]. In a reform simulation the authors find that an actuarially fair system would raise the male activity rate from 45% of 1995 to more than 70%.

In short, the recalled results predict a substantial reduction of retirement rates of older cohorts due to the reforms and, consequently, an improvement of activity rates, although at the moment we lack a precise quantification of the long run effects of these reforms.

Yet, a few works cast doubts on these conclusions: Miniaci (1998), finds out that retirement choices are relatively rigid with respect to a 10% increase of the pension-to-last-wage ratio. Spataro (2000a), adopting the *Option Value* framework for Italian male employees, brings evidence of an empirical puzzle due to excess of retirement at age 60. In other words, he finds out that the consideration of economic factors only partially explains the spike of retirees at that age, which, again, leads to suspect some rigidity of the retirement behavior. The nature of such peak, however, remains unexplained. Brugiavini e Peracchi (2001), using the National Social Security (INPS) dataset, obtain mixed results about the effects produced by some tightening reforms for private sector employees, in that the modified retirement hazards do not imply substantial changes in the mean retirement age. In their estimations the authors use a mix of dummy variables for explaining the peaks of hazard rates at certain ages, which, although improving significantly the model fit, leaves the empirical puzzle of the age-60-spike still unexplained from an economic standpoint.

Finally, a very similar conclusion is obtained by Spataro (2002b): by adopting a duration analysis on retirement of Italian male householders, the author finds out a strict preference for early retirement which would tend to offset the impact of future reforms on activity rates[32]. All this considered, it can be said that the puzzling results of the recent works give room to further investigation about the computation of Social Security incentive measures and the preferences underlying the retirement choices of Italian workers.

4. Two empirical applications on retirement behavior in Italy

In this section I present a comparison of two dynamic models dealing with retirement choices: a discrete time Duration model (DM) and the *Option Value* model (OVM). Both applications focus on the analysis of individual preferences of Italian male workers and are able to cope with the "forward looking" nature of the choice. In particular, the purpose of this work is to contrast the performance of both models in assessing the significance of and in explaining some of the major "stylized" facts mentioned above, that is: a) whether there is "statistically" significant difference between Private and Public Sector employees; b) the nature of the spike at age 60. Before presenting the data and the estimation strategy, I introduce the meaning of several measures of Social Security incentives for postponing retirement used in the empirical analysis.

[30] The author selects two groups: those who at 31/12/1992 had paid contributions for more and less than 15 years, respectively. The estimates, however, are probably distorted by the stop to "seniority pensions" imposed by the government in 1993 (on this point see section 5).

[31] Blondal and Scarpetta (1998) perform a longitudinal, macroeconomic analysis using an OECD countries panel. However, the authors reckon that a relevant amount of the variance among countries is explained by the "fixed effect", that is by non-economic (and unspecified) elements.

[32] The work by Colombino (2002) is somewhat in the middle, in that the author finds a *small but not irrelevant* elasticity of the number of retirees with respect to the pension amount.

4.1. Social Security incentive measures

I now turn to the presentation of the Social Security incentive measures used in the analysis, starting from the one referred to as MCR. Let us image an individual is assessing the possibility of leaving her job and, thus, retiring in the current year, the latter being also the first period in which eligibility is achieved. I assume that decisions (and wage or pension benefits) occur at the beginning of each year; the agent can decide whether working or not for one year more, but the amount of time on the job is given and normalized to 1. Thus, by leaving in current year t, the agent gives up her current wage (net of pension payroll tax) and obtains a flow of pension benefits up to year D (when she dies) which is usually referred to as "SS wealth"[33]. Formally:

$$F_{L,t} = (1-\tau)\cdot W_{L+1,t} - \sum_{i=1}^{D-t} \frac{P_{L,t+i-1}}{(1+r)^{i-1}}, \qquad [37]$$

where $W_{L+1,t}$ is the wage of year t after $L+1$ years of work, τ is the contribution tax rate, $P_{L,t+i-1}$ is the annual pension amount corresponding to the minimum number of contribution year payments *(L)* needed for eligibility, r is the interest rate, supposed constant for simplicity.

On the other hand, In case she keeps on working another year, she "gains" the flow of benefits:

$$F_{L+1,t} = -\sum_{i=1}^{D-(t+1)} \frac{P'_{L+1,t+i}}{(1+r)^{i}}. \qquad [38]$$

By subtracting expression [38] from [37] we get the *Marginal Cost of Retiring* in year t, which is:

$$MCR_{L/L+1,t} = (1-\tau)\cdot W_{L+1,t} + \sum_{i=1}^{D-(t+1)} \frac{P'_{L+1,t+i}}{(1+r)^{i}} - \sum_{i=1}^{D-t} \frac{P_{L,t+i-1}}{(1+r)^{i-1}}. \qquad [39]$$

More generally, in each future year $t+j$, one has:

$$MCR_{L+j/L+1+j,t+j} = (1-\tau)\cdot W_{L+j+1,t+j} + \sum_{i=1}^{D-(t+j+1)} \frac{P'_{L+j+1,t+j+i}}{(1+r)^{i}} - \sum_{i=1}^{D-(t+j)} \frac{P_{L+j,t+j+i-1}}{(1+r)^{i-1}} \qquad [39']$$

with $j=0,1\ldots(\overline{L}-L)$, where $\overline{L}$ is the maximum number of working years fixed by the law[34]. Finally, by dividing expression [39'] by the current wage, we get the *Rescaled MCR*:

$$RMCR_{L+j/L+1+j,t+j} = \frac{MCR_{L+j/L+1+j,t+j}}{W_{L+j+1,t+j}}. \qquad [40]$$

[33] For the sake of simplicity I abstract from survivor benefits and survival probabilities. The latter are however accounted for in the estimations of all parameters presented in the section Finally, I assume that individuals start paying contributions at the beginning of their working careers.

[34] See Spataro (2000b) for a more extensive analysis of the MCR and of its steady state properties for Italy.

Intuitively, should the benefit formula be actuarially fair (or pensions not provided at all), the cost of retiring would be the current wage, thus reproducing a well known result stemming from microeconomic theory on labor supply. In all other cases, being the cost either bigger or lower than the wage, a distortion of work/leisure choice and, consequently, welfare losses would be brought about[35]. Notice that the *RMCR* is quite close to the implicit tax/subsidy of postponing retirement used, among others, by Brugiavini (1999) and by Coile and Gruber (2000), which I indicate as $B_{L+j/L+1+j,t+j}$; it is defined as the ratio between the expected present value of future pension benefits accrual (with negative sign), obtained from postponing retirement by one year, and the current period wage. Formally:

$$B_{L+j/L+1+j,t+j} = -\frac{1}{W_{L+j+1,t+j}}\left[\sum_{i=1}^{D-(t+j+1)} \beta^i P'_{L+j+1,t+j+i} - \sum_{i=1}^{D-(t+j)} \beta^{i-1} P_{L+j,t+j+i-1}\right] \equiv -\frac{ACCR_t}{W_{L+j+1,t+j}} \qquad [41]$$

where β is the intertemporal discount factor; now, supposing β and r equal to 1 and 0 respectively for the sake of simplicity, the following relationship holds:

$$RMCR_{L+j/L+1+j,t+j} = \left\lfloor -B_{L+j/L+1+j,t+j} + (1-\tau)\right\rfloor . \qquad [42]$$

Consequently, if the system is actuarially fair, so that $MCR_{L+j/L+1+j,t+j} = W_{L+j+1,t+j}$, (or *RMCR=1*) then $B_{L+j/L+1+j,t+j} = -\tau$. On the contrary, there is an incentive to early retirement if and only if

$$MCR_{L+j/L+1+j,t+j} < W_{L+j+1,t+j} \Leftrightarrow RMCR_{L+j/L+1+j,t+j} < 1 \Leftrightarrow B_{L+j/L+1+j,t+j} > -\tau . \qquad [43]$$

From the relationships above it can be said that *the third inequality to hold, rather than the positive sign of B (that is a positive accrual) is a necessary and sufficient condition for the presence of early retirement incentives*[36]. In this sense, the *(R)MCR* seems more coherent with the microeconomic theory on labor supply and gives an immediate and exact measure of the incentive to early retirement.

A straightforward extension of such parameter is what I call the *Minimum Cost Value* (*MCV*) of retirement, that is the *difference between the minimum marginal cost of postponing retirement in the future and the current date marginal cost*. Formally:

$$MCV_t = \min\left(MCR_{t+j} - MCR_t\right) \text{ with } j=1 \ldots \left(\overline{L} - L\right). \qquad [44]$$

In other words, this parameter allows for possibility that individuals: i) face a longer time-horizon than a single year time-span; ii) compare not just the *difference* between flows of benefits (like in the *Peak Value* case) or *values* (like in the Option Value) but the "marginal

[35] The analysis of Social Security systems optimality was presented in the seminal work by Aaron (1966); the reconsideration of such conditions under endogeneity assumption of labor supply is provided by Hu (1979) and Breyer and Straub (1993). For a macroeconomic, static analysis of the links between employment and social security see also Casarosa (1996).

[36] This is property does not hold in case the subjective discount rate (β) is different from the interest rate. A deeper discussion of this case is more complex and beyond the scope of this work; however, as an example, it can be shown that in a funded system and for reasonable values of the wage growth rate and the interest rate, the MCR will be greater than (lower or equal to) the current wage if and only if $\beta < (\geq) r$. (The formal demonstration of this proposition is available upon request to the author).

costs": in particular, in case the marginal cost reduces as at some older age, so that $MCV_t<0$, it is more convenient for individuals to postpone retirement. Again, were the Social Security system actuarially fair, (so that the *MCR* in each period would equal the current salary) the decision to retire would be completely led by the difference between future and present wages. Henceforth, in order to disentangle the effect of wage changes from the Social Security variation, I will also use a rescaled measure of the *MCV*, that is the difference between the minimum expected future *RMCR* and the current one:

$$RMCV_t = \min\left(RMCR_{t+j}\right) - RMCR_t \qquad \text{with } j=1\ldots\left(\overline{L}-L\right). \qquad [45]$$

Analogously, one can extend the same reasoning to the *Accruals*, and build-up the following measure, which I call the Minimum Tax Value (*MTV*); more precisely, I define such measure as *the difference between the Maximum expected value of the Accruals* (with reversed sign, which can be interpreted as the minimum tax levied upon the decision of anticipating retirement by one year) *and the value* (with reversed sign as well) *associated to the current year*. By calling the negative of the Accrual as the Absolute Tax (ATAX), we get:

$$MTV_t = \left(\min\ ATAX_{t+j}\right) - \left(ATAX_t\right) \qquad \text{with } j=1\ldots\left(\overline{L}-L\right). \qquad [46]$$

Again, both *(R)MCV* and *MTV* measures indicate that the higher the difference between future and current costs (taxes) comprised in the decision of retirement, the more likely individuals will tend to postpone the year of retirement.

Finally, I will compare the above parameters with the existing Peak Value proposed by Coile and Gruber (2000), defined as the difference between the Maximum future expected Social Security Wealth and the current one, and the Option Value of delayed retirement, set up by Stock and Wise (1990). For the sake of comparability with previous estimates carried out by Brugiavini and Peracchi (2001), I assume an intertemporal discount rate factor β of 0.985, the marginal utility of leisure (*k*) equal to 1.25 and a risk aversion parameter (*a*) equal to unity[37]; survival probabilities are taken from tables provided by ISTAT for the years considered, while future pensions (before reforms) are indexed by 1.5% per year. Finally, as for *RR* measure, its relatively simple formulation (in fact it is defined as the ratio of the first pension to the last wage) makes it immediate to consider such parameter a "short-sight" indicator; however one must bear in mind that the interpretation above is a simplification, in that the *RR* represents also the desired standard of living for the future and, thus, it probably comes out of some optimization process of smoothing consumption over time; more precisely, such measure is meant to grasp the "wealth effect" of retirement. In the remainder of the work I will refer to SSW and to RR as "static incentives" and to the others as "dynamic incentives". Among the latter, I will discriminate between "short-sight" (or "one-year dynamic") and "forward-looking", including the (R)MCR, Accrual, Tax/Subsidy in the former subset and the Peak Value, (R)MCV, the MTV in the latter.

4.2. Data and Empirical Strategy

For the empirical analysis I use the Bank of Italy Survey on Income and Wealth of Italian Households (SHIW), by focusing on male dependent householders aged 48 to 64 and belonging to the partially rotating panel available from 1989 through 1993[38]; more precisely,

[37] I have also tried to compute all incentives with different specifications of parameters, which however do not change the qualitative pattern of the incentives and conclusions.

[38] See Spataro (2002b) for a detailed explanation of the selection strategy adopted for the data

I select panel householders who were still at work or retired by the interview year (or by the previous year); I also drop individuals who retired before the achievement of Social Security eligibility (so-called "Pre-pensionamenti"). The reason for selecting this relatively out-of-date sample, despite of the numerical and informative losses if compared to the subsequent waves of interviews, relies on the evidence that the 1993 (Amato) and 1995 (Dini) reforms have distorted retirement behavior in those years: namely, in 1993 and 1995 the government impeded "seniority retirement" in order to reduce the financial bleeding of the system. Thus, the analysis of 1989-1993 panel should make me avoid the risk of "noisy" data (provided that the reforms were unexpected).

Since the Survey provides a lot of retrospective information (concerning, for example, the year of retirement, working status and so on) I build up a sample that, by means of imputations, seeks to exploit such information as much as possible. In this respect it is worth noting that at least two possible strategies might have been adopted. The former relies on current and retrospective information obtainable from the SHIW 1995 cross-section (the first wave in which questions on individual contribution payments to the Social Security Fund have been reported); the latter consists in the use of the 1989-1993 panel records. Both options imply the loss of some relevant information, which, *a priori*, does not make one approach superior to the other[39]. However, trying to minimize such losses, to use panel information and to trace back individual specific "time varying" covariates (especially family composition), I work out the following strategy[40]:

1) I select panel male householders (or head's partners) with continuous working careers during their last years of employment, belonging to the age 48-64 interval and still at work or just retired by the first interview;
2) next, I replicate observations for the periods not covered by the Survey (i.e. even years from 1988 to 94) by exploiting retrospective information (on retirement year, family composition and working status changes and so on). However, in order to avoid the risk of imputing information too far in time since the interview, I transfer the original records backward and/or forward by one year only (and eliminate individuals as they retire or become older than age 64).

By following this strategy, starting from the 1065 original panel individuals and the 2129 original person-year records, I end up with 4283 person-year observations covering the whole 1988-1995 period; such figure lowers to 1979 by selecting eligible individuals only, and, finally, to 1314 when picking up observations through year 1992. The last sub-sample is the one used for econometric estimations of the DM and the OVM.

The main characteristics of the sample are depicted in Table 2c: more precisely, individuals are evenly distributed between Public and Private Sector, although about 3/4th of the eligible workers are State employees, due to the more favorable rules the latter have been enjoying before reforms. About 94% of individuals are married and by 3.9 years older than their spouses. Among eligible workers, almost 7% and 27% happen to be within their first and third year of eligibility respectively. Finally, house owners are about 74% of the sample, although percentages are different when considering Public and Private Sector employees separately (which I do not report in the table) : 76% and 69% respectively.

4.3. Estimation strategy for Social Security incentive measures

As for the computation of the Social Security incentives, the major issues are the following:

[39] In particular, by the first strategy information concerning the family composition would be lost, while by the second observations one cannot use the whole stock of retirees, but only yearly flows.
[40] See Coile and Gruber (2000) for a similar approach.

1) both retrospective and future wages are needed: the former are necessary for computing the "pensionable earnings" (a sort of accrued capital linked to years of contributions and to the last wages); the latter are needed to compute the life-time earnings and some of the forward looking variables;

2) wages reported in the Survey are net of taxes, while the formula of pension benefits requires pre-taxes wages;

3) contributions paid to the National Fund are provided only in 1995 SHIW interviews, while the wage offered to the new retirees has to be completely imputed.

In order to overcome these problems:

1) I gross up wages by using information about tax rates and releases due to family composition;

2) I perform a two-stage estimation: precisely, I first impute both wages (past, current and future) and contributions to the sample and, secondly, I estimate the Duration model on a set of covariates X_{ji}. In order to obtain independent samples for the two steps, I regress wages and contributions by using the 1989 to 1995 and 1995 cross sections, respectively.

An alternative way for obtaining the wages could have consisted, for employees, in applying a constant growth rate to present salaries and, for retirees, doing the same after inferring wages from reported values of the first *RR* attained as a retiree; however, I choose the first solution in order to keep enough heterogeneity in the Social Security incentives to be exploited in the estimation, since for the measures analyzed in this work the most relevant source of variation is not the *wage level* but, rather, the *wage growth rates*: in other words, the higher the variability of the latter, the higher the heterogeneity of Social Security incentives and the more precise is the inference one can obtain from the data.

Furthermore, the choice of the covariates entering the hazard equation is constrained by the identification problem brought about by the adopted two-steps procedure (see Arellano and Meghir (1992) and Meghir and Whitehouse (1996)): in other words, identification restrictions about exogeneity of the instruments to be used both in wages and contributions estimations are needed. Hence, for the first step regression I use as identifying instruments cohort effects, number of years at work, sector of activity, working careers, regional residence, education, time dummies and interaction effects[41].

Notice that the number of working years used as instrument would be endogenous to the model, since it depends on the decision to retire estimated in the second step; however, I tackle this issue by: a) using independent samples for the two steps; b): correcting the composition effect for wages by using Heckman's two-steps procedure: in other words, wages are "purged" from the "selectivity bias" by conditioning the wage equation on the probability of being at work; for contributions estimates such correction was not necessary since the latter distortion did not turn out to be significant under different specifications of the selection equation and both by using maximum likelihood or two-steps estimators[42]. Thus, as for the wages, I run a two-step OLS of log-wages over the pooled data belonging to years 1989-1995 interval. The estimation of contributions is run carried out by means of an OLS regression on the 1995 data only. Both variables are then imputed forward and backward to the panel sample. Finally, after the imputation process, I estimate a Proportional Hazard model with complementary log-log link, using as duration variable a quadratic polynomial of age and as covariates: family composition, average lifetime wages and number of income receivers in the household, working sector, house ownership and marital status; (pooled) regional

[41] This assumption can be interpreted by saying that such covariates do not enter directly the hazard function, but only via wages and contributions. Notice that years of contributions paid to the National Social Security Fund and life-time working years do not necessarily coincide, although they are highly correlated.

[42] See Greene (1999) and Maddala (1983) for Heckman's correction model. The exact regression specifications and results for contributions and wages are available under request to the author.

unemployment rates are used as well in order to account for business cycle effects. Besides this, I control for the occupational status of the spouse and the spouses' age difference; the latter variable is meant to detect the presence of coordination within couples upon the timing of retirement. Furthermore, I try several specifications by means of dummy variables to test the relevance of binding constraints and of other non-economic factors in determining the age-60-peak of retirement hazards. Finally, since some of the covariates are derived from the estimated wages and contributions, which have been previously estimated and enter non-linearly the latent equation, I correct the regression bias by bootstrapping the standard errors[43].

As for the *Option Value* model, I account for heterogeneity by specifying different parameters according to working Sector (Public and Private Sector) and age (younger or older than 60) respectively.

4.4. Results

Results concerning Social Security incentive measures are presented in Table 3: precisely, only the mean values and standard deviations (expressed in 1992 ten thousand lira) are reported; a more detailed analysis of the age distribution and standard deviations of such measures is provided in Spataro (2002a).

In order to assess the amount of (unexplained) heterogeneity comprised in Social Security incentive measures, in Table 3 I also report the R-squared stemming from OLS regressions of such incentive parameters over age dummies, current and lifetime wages and working Sector. These figures show that, although this set of covariates has some ability to explain the pattern of Social Security incentives, the overall explanatory power is relatively small. With the exception of SSW, which is in fact highly correlated with current and lifetime wages, the other Social Security incentives show a substantial amount of variation which is otherwise basically uncorrelated with retirement. As a consequence one may be relatively confident about the capability of econometric estimates to capture the "net" effect of Social Security incentive measures on retirement choices[44].

I now turn to present the econometric estimations of the retirement models (which are carried out over the eligible workers sub-sample), starting from the DM. Results of regressions explicitly accounting for omitted variables are not reported here, since, after several trials, there comes out no significant evidence of biased coefficients due to unobserved heterogeneity. As a consequence, individual-specific heterogeneity is only accounted for by clustering standard errors over individuals.

The first finding concerning the Social Security incentive measures, is that the RR measure performs fairly better than SSW (either in absolute value or in terms of the current wage, see Table 4). In fact this is not a completely unexpected result, given the high correlation of SSW with lifetime (and present) wages unveiled in the analysis of Social Security incentives heterogeneity (see Table 3). For this reason I use the RR in the next econometric specifications dealing with the dynamic Social Security incentive parameters. However, notice that coefficients for both SSW and RR parameters relating to the Private

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[43] Given that the asymptotic properties of the statistics are non-normal and likely to be non-standard as well, it seems sensible not to pose any parametric assumption on their distribution.

[44] As for the expected signs of the new Social Security incentive measures introduced in this work, by definition the MCR is expected to negatively affect the probability of retiring by the current year. Secondly, if for an individual the minimum future cost (or tax) comprised in the choice of anticipating retirement by one-year is higher than the one resulting from the current year decision (i.e. the RMCV and the MTV are negative) one would expect such individual to exit labor force within the current year. In other words, the higher the difference between the future and present costs of retirement, the higher the probability to retire at the current age. As a consequence both the RMCV and MTV coefficients stemming from econometric estimations of the hazards should have positive signs.

Sector workers are hardly ever significant, although presenting the correct sign**:** this is probably due to the existence of binding eligibility constraints which, contrarily to the Public Sector workers, do not allow individuals to choose their optimal level of Social Security wealth. I will explicitly deal with this issue later on. Finally, State workers appear to be less conditioned by the level of future earnings, although the coefficients are significant for both categories: a combined interpretation of these findings could be that the State workers are relatively more eager to retire, although they can delay retirement until the achievement of their own desired level of Social Security wealth accumulation.

As for the one year dynamic incentive measures, results in Table 5 show that these parameters fall short in explaining the variability in the retirement hazards, since in general their coefficients are both not significantly different from zero and wrong signed. By the same token, the performance of Social Security dynamic incentives is poor, as confirmed by the findings depicted in Table 6: coefficients associated to the first two Social Security measures are not significant, and only the OV coefficients (and the Public Sector Peak Value coefficients) present the correct sign. However, the MTV coefficients turn out to be significant and with the expected sign, both for Public and Private Sector employees. As for the MTV measure, an intuitive explanation of the findings above is that the time pattern of the tax levied on retirement is relevant to individuals, so that they anticipate retirement when the differences in between future and present taxes on retirement is too high. In any case, I can say that the forward looking attitude of individuals is not rejected, although for only one of the Social Security incentive measures adopted.

Turning to the nature of the hazards spike occurring at age 60, I contrast three possible explanations: a) Age 60 is relevant per se (a sort of "rule of thumb" induced by social rules); b) Only eligibility constraints do matter, in the sense that a sizable fraction of individuals retire as soon as they are allowed to do so by the law. In this case age 60 is relevant inasmuch as it "happens" to be the age in which most binding eligibility constraints disappear; c) the third hypothesis is a mixture of the two. Tests are performed, respectively, by verifying the statistical significance of: a) a dummy variable for age 60; b) a dummy variable activating when individuals are within their third year of eligibility[45]; c) a dummy which is the interaction of the previous two. Results (the best of which are reported in the tables, i.e. those stemming from the last specification) show that the second hypothesis is never significant while the others are statistically different from zero and with the correct sign. However, the third specification appears to fit better the data, with a 5 points improvement of the Log likelihood on average if compared to the first. Thus, the evidence that eligibility arguments turn out to be relevant only when associated with the age 60 dummy, leads to concluding that some non-economic factor (such as "social rules") is likely to affect retirement decisions as well.

As for macroeconomic factors, the regional unemployment rates do not affect retirement substantially. Among other socio-economic variables, mean future wages appear to affect negatively the probability of retirement (also specifications incorporating current wages were tried out, yet without producing relevant information): this finding clearly supports Coile and Gruber (2000) intuition about the relevance of such variable in retirement choices: in fact, if the reward of the alternative option (i.e. employment) is high, individuals tend to go on working (this may also be interpreted in the sense that leisure is an inferior good or that for high-wage workers employment is a pleasure). Age affects retirement substantially, even though with reversed sings if compared to Chan and Stevens' results: in fact in the present analysis the coefficient on age is positive and significant and the squared term is negative and significant, which seems more coherent on intuitive grounds; in any case the effect of age,

[45] Since contributions have been estimated, I preferred to use a broader measure instead of the very first year of eligibility.

given the values of parameters, keeps positive throughout the age interval under investigation, although its contribution decreases as individuals get older. Among the other covariates, being married is likely to cause a postponement of retirement, while the number of other individuals living in the household affects the hazards in the opposite way, although in general these parameters do not appear significant. However, interestingly among married State workers the magnitude of the age difference with the spouse lowers the probability of leaving the labor force, which brings some evidence of coordination among couples in the timing of retirement. For Private Sector workers results concerning marital status and family composition are quite similar; however, the coefficients on the number of income receivers in the household and on house ownership present opposite signs for the two working categories. A plausible interpretation of such findings could be that Private Sector individuals are more constrained on income and wealth grounds, so that it takes more time to them to reach the desired standard of leaving for old age: in fact, contrary to State employees, house-ownership is still a significant concern for such workers by the end of their working careers.

By comparing these results with those of the OV model, it clearly emerges that the DM models turns out to be superior, in terms of Log-likelihood values: in fact the DM produces a value which is significantly higher than those resulting from the OV estimations (see Table 7).

Focusing on the latter model, preliminarily two issues are worth mentioning: first, the variance is never significant and, more importantly, strongly correlated with the risk aversion parameter α: this fact represents a source of frailty of the model, which does not always allow to obtain conjugated estimates of both parameters. Second, also several parameters related to Private Sector workers are not significantly different from zero. Both results are likely to be imputed to the quality of the data used in this work[46].

Turning to the description of the parameters, from all specifications presented it emerges that Italians evaluate leisure substantially, are very risk averse and discount strongly the future. In particular, by observing estimations of the "marginal utility of leisure" (i.e. parameter θ) stemming from model 1, a Public (Private) Sector worker would exchange 1.56 (1.33) lira of consumption when working with 1 lira of consumption as a retiree (equivalently, the preferred RR is about .64 (.75)). On the other hand, both the discount rates (γ) and the risk aversion parameter (α) are very low. As a consequence, although the forward looking behavior incorporated in the OVM cannot be rejected (especially for Public Sector workers, whose estimations appear more robust) both the high risk aversion and the discounting rates reveal that future events do not play as a relevant role as the current ones in affecting the probability to retire.

Finally, in order to account for the peak of hazard rates at age 60, I test the hypothesis that this phenomenon is due to a change in the marginal utility of leisure occurring by that age. Results, reported in the third column of Table 7 (model 2), show that this explanation is quite plausible for Public Sector individuals, while is not completely satisfactory for the other workers: in fact the marginal utility parameters ($\theta 1$, related to ages higher or equal to 60 and $\theta 1$, applying to the others) although substantially different, are not significantly different from zero for Private Sector employees.

Concluding, it can be said that the standard specification of the OVM provides an elegant and useful framework for micromodeling retirement decisions; however, it leaves unexplained much of the variability shown by the Italian data, which deserves more attention in future research.

[46] This correlation between the mentioned parameters is demonstrated by the variance-covariance matrix, which is not reported here but is available under request to the author. In any case, by looking at the formula provided in section 2.4.1, such correlation seems also to be imputed to the OVM formulation itself, rather than to the data only.

5. Conclusions

In this work I carry out an overview of the most recent developments in micromodeling retirement choices.

I classify the models proposed by the "retirement literature" into two categories: static and dynamic models. The main difference between the two approaches is whether they match the "sequential" nature of the retirement choice or not. In turn, I discriminate among the static approaches according to whether they allow for the discrete nature of the retirement choice, the forward looking assessment of economic incentives and the presence of uncertainty. As for the dynamic models, I sketch the main features of the *Option Value* and the Dynamic Programming models.

The degree of sophistication of economic theory and of econometric specifications of retirement models have increased dramatically. The promising results obtained by the works carried out so far are boosting further developments: on the one hand, explaining joint retirement and saving decisions, private pensions and health care interaction in an unified framework are some of the most challenging objectives on the researchers' agenda. On the other hand, very interesting steps into modeling joint labor supply decisions in the family context have been already taken: the issue is both interesting *per se* and can improve the level of realism of future applications, such as economic microsimulation.

In any case, the increase in the models complication is not priceless: in general, the cost is lower "flexible", high computer-time demanding procedures and specification dependence. Also good longitudinal or panel data availability is a necessary condition for implementing more complex and robust models.

As an example of possible applications, in the second part of the work I set-up a comparison between two of what I classify as "dynamic models": a Duration (DM) and an *Option Value* model (OVM), respectively. The data consist of retirement choices of male Italian employees drawn from the Bank of Italy Survey on Income and Wealth of Italian Households before 90's reforms; in particular, I assess the explanatory significance of the working Sector and the role of both strictly economic incentives (to early retirement) and of other socio-economic variables. As for Social Security incentive measures entering the hazard equation as covariates, I set-up several new parameters which, based on microeconomic theory of labor/leisure time allocation, aim at capturing the distortion brought about by the pension rules via the actuarial unfairness of the benefits formula.

Econometric estimates show that the DM performs better than the OVM, despite the latter is "more appealing" for economists in terms of economic significance and intuitive interpretation of parameters. Thus, in this work the trade-off between data tractability and model sophistication turns out to be even worse than expected, in that the more sophisticate model does not produce better estimates.

Summarizing, the other major results of the applied analysis are the following:

1) The behavior of individuals belonging to the Private Sectors turns out to be significantly different from that of Public Sector employees, due to less favorable Social Security rules and, also, to *intrinsically different preferences.*

2) Economic incentives play a crucial role in affecting the timing of retirement of male employees and, although forward looking behavior cannot be rejected for both models and for both State and Private Sector workers, results seem to bring evidence that individuals highly weigh the present relative to the future and are particularly risk averse.

3) The empirical puzzle of the age 60 spike of exit hazards cannot be directly imputed to a change of preferences occurring at such an age (at least for Private Sector employees), but, rather, to eligibility constraints and, possibly, to other unexplained factors (such as "social rules") which should be investigated in the future.

4) Finally, the household dimension of the retirement choice in Italy should be explicitly accounted for and explored in future research, in that the DM brings some evidence of coordination among couples in the timing of retirement.

Bibliography

Aaron H. (1966) "The Social Insurance Paradox", *Canadian Journal of Economics and Political Science*, vol XXXII, n.3.

An M.Y, Christensen B.J. and Gupta N.D. (1999) "A Bivariate Model of the Joint Retirement Decisions of Married Couples", Centre for Labour Market and Social Research, WP 99-10, December.

Antcliff S. (1993) "An Introduction to DYNAMOD", DYNAMOD Technical Paper No. 1, National Centre for Social and Economics Modelling, University of Camberra.

Arellano M. and Meghir C. (1992) "Female Labour Supply and On-the Job Search: An Empirical Model Estimated Using Complementary Data Sets", *Review of Economic Studies* 59: 537-557.

Banca d'Italia: Appendice alla Relazione Annuale, several years.

Banca d'Italia: *I Bilanci delle Famiglie Italiane negli Anni 1977-199*5. Supplementi al Bollettino Statistico (Note Metodologiche ed Informazioni Statistiche), several years

Bianchi C., Romanelli M. and Vagliasindi P. (2001) "Inequality and poverty among pensioners: microsimulating the role of indexing lowest pensions to wages", *ECOFIN*, Istituto Economia e Finanza, Università Parma.

Blau D.M. (1998) "Labor Force Dynamics of Older Married Couples", *Journal of Labor Economics* 16(3): 595-629.

Blondal S. and Scarpetta S. (1998) "The Retirement decision in OECD Countries", AWP 1.4, OECD, Paris.

Bosi P. (1995) "Un punto di vista macroeconomico sulle caratteristiche di lungo periodo del nuovo sistema pensionistico italiano", *Politica Economica* 11(3): 325-56.

Bosi P. (1997) "Aumentare l'età pensionabile fa diminuire la spesa pensionistica? Ancora sulle caratteristiche di lungo periodo della riforma Dini", *Politica Economica* 13(2): 295-304.

Boskin M.J. and Hurd M.D. (1978) "The effect social security on early retirement", *Journal of Public Economics 10:* 361-377.

Breyer F. and Straub M. (1993) "Welfare Effects of Unfunded Pension Systems When Labor Supply Is Endogenous", *Journal of Public Economics* 50(1): 77-91.

Brugiavini A. (1999) "Social Security and Retirement in Italy", in Gruber J e Wise D (edited by): *Social security and retirement around the world*. NBER Conference Report series. Chicago and London: University of Chicago Press.

Brugiavini A. and Peracchi F. (2001) "Micro Modeling of Retirement Behavior in Italy", prepared for the Workshop: "Socio-demographic factors and the future of the welfare state in Italy", March, Frascati (Rome), mimeo.

Burbidge J.B. and Robb A.L. (1980) "Pensions and Retirement Behaviour", *Canadian Journal of Economics*, 13: 421-437.

Burtless G. (1986) "Social Security, Unanticipated Benefit Increases, and the Timing of Retirement", *Review of Economic Studies*, LIII: 781-805.

Burtless G. and Hausman J. (1980) "Individual retirement decisions under employer provided pension plan and social security", mimeo Massachusetts Institute of Technology.

Casarosa C. (1996) "Alcune semplici relazioni fra sistema previdenziale, vincolo distributivo, occupazione e disoccupazione", *Rivista di Politica Economica* 86(7-8): 27-60.

Castellino O. (1994) "La riforma della previdenza sociale, ovvero, il rapporto che non fu scritto", *Moneta e Credito*, Dicembre, 188: 515-540.

Castellino O. (1995) "Redistribution Between and Within Generations in the Italian Social Security System", *Ricerche Economiche* 49(4): 317-327.

Castellino O. and Fornero E. (2001) (eds): *La riforma del sistema previdenziale italiano,* Bologna, Il Mulino.

Chan S. and Stevens A. (2001) "Retirement Incentives and Expectations," NBER Working Paper No. 8082,

Coile C. and Gruber J. (2000) "Social Security and Retirement", *NBER Working Paper*, No.w7830, August.

Colombino U. (2002) "A Simple Intertemporal Model of Retirement Estimated on Italian Cross-Section Data", mimeo.

Commissione ministeriale (2001) *Verifica del sistema previdenziale ai sensi della legge 335/95 e successivi provvedimenti, nell'ottica della competitività, dello sviluppo e dell'equità*, Relazione Finale, Rome, Ministero del Welfare.

Cox D.R. (1972) "Regression models and life-tables (with discussion)", *Journal of Royal Statistical Society*, Series B 34: 187-220.

Diamond P. and Hausman J. (1984) "Individual Retirement and Savings Behavior" *Journal of Public Economics*. 23(1-2): 81-114.

Engen E.M, Gravelle J. and Smetters K. (1997) "Dynamic Tax Models: Why They Do the Things They Do", *National Tax Journal.* (September) 50 (3): 657-82.

Feldstein M. (1974) "Social security, induced retirement and aggregate capital accumulation", *Journal of Political Economy*, 82: 905-926.

Ferraresi P.M. and Fornero E.(2000) "Costi e distorsioni della transizione previdenziale ed effetti correttivi di alcune ipotesi di riforma", *Politica Economica*, Aprile, 1: 3-47.

Fornero E. (1999) *L'Economia dei Fondi Pensione, Potenzialità e limiti della previdenza privata in Italia*, Bologna, Il Mulino.

Galler H.P. (1997) "Discrete-Time and Continuous-Time Approaches to Dynamic Microsimulation", Paper presented at the Microsimulation in New Millennium: Challenges and Innovations Workshop, Cambridge, August.

Geweke J. (1995) "Monte Carlo Simulation and Numerical Integration", Federal Reserve of Minneapolis Research Department Staff Report 192.

Greene W.H. (1999) *Econometric analysis*, IV edition, New York, Prentice Hall.

Gribble S. (2000) "LifePaths: A Longitudinal microsimulation model using a synthetic approach", Chapter 19 in *Microsimulation in Government Policy and Forecasting* (Gupta A. and Kapur V. eds.) Elsevier, Amsterdam & New York.

Gronchi S. (1995) "Previdenza, riforma minata", *Il Sole 24Ore*, 30 giugno.

Gruber J. and Madrian B.C. (1995) "Health Insurance Availability and the Retirement Decision", *American Economic Review* 84(4): 938-948.

Gruber J. and Wise D.A. (eds.) (1999) *Social security and retirement around the world,* NBER Conference Report series; Chicago and London: University of Chicago Press.

Gupta A. and Kapur V. (eds) (2000) "*Microsimulation in government policy and forecasting*", Elsevier, Amsterdam & New York.

Gustman A.L. and Steinmeier T.L. (1986a) "A disaggregated structural analysis of retirement by race, difficulty of work and health", Review of Economics and Statistics 67 (3): 509-513.

Gustman A.L and Steinmeier T.L. (1986b) "A Structural Retirement Model", *Econometrica* 54 (3):555-584.

Gustman A.L. and Steinmeier L.S. (1994) "Retirement in a Family Context: A Structural Model for Husbands and Wives", NBER Working Paper No. 4629. Cambridge, MA: National Bureau of Economic Research.

Hausman, J.A. and Wise D.A. (1985) "Social Security, Health Status, and Retirement", in David A. Wise, ed., Pensions, Labor, and Individual Choice. Chicago: University of Chicago

Hotz V.J., Miller R.A., Sanders S. and Smith S. (1993) "A simulation Estimator for Dynamic Models of Discrete Choice", *Review of Economic Studies,* 60: 397-429

Hu S.C. (1979) "Social Security, the Supply of Labor, and Capital Accumulation", *American Economic Review* 69(3): 274-83.

Hurd M.D. (1990) "The Joint Retirement Decision of Husbands and Wives", in *Issues in the Economics of Aging*, 231-254.

ISTAT (1997) "Previsioni della popolazione residente per sesso, età e regione, base 1.1.1996", C*ollana Informazioni*, n. 34.

ISTAT: *Indagine sulle forze lavoro*, various issues.

Jenkins S. (1995) "Easy Estimation Methods for Discrete Time Duration Models", *Oxford Bulletin of Economics and Statistics*, 57(1): 129-137.

Johnson R.W., Davidoff A.J. and Perese K. (2000) "Health Insurance Costs and Early Retirement", Paper presented at the Allied Social Sciences Meeting. Boston. January 8.

Kalbfleisch J.D. and Prentice R.L. (1980) *The statistical analysis of failure time data*, John Wiley and Sons, New York, N.Y.

Karoly, L.A., and Rogowski J.A. (1994) "The Effect of Access to Post-Retirement Health Insurance on the Decision to Retire Early", *Industrial and Labor Relations Review* 48(1): 103-123.

Laditka S. (1996) "Individuals 'Lifetime Use of Nursing Home Services: A Dynamic Microsimulation Approach", Papers in Microsimulation Series, n.3, Maxwell Centre for Demography and Economics of Ageing.

Lancaster T. (1979) "Econometric methods for the duration of unemployment", *Econometrica* 47: 939-956.

Lazear E.P. (1986) "Retirement from the Labor Force", in Handbook of Labor Economics, Vol. I, eds. O. Ashenfelter and R. Layard, Elsveier.

Lumsdaine R. and Mitchell O. (1999) "New developments in the Economic analysis of Retirement", in Handbook of Labor Economics, Vol. 3, eds. O. Adhenfelter and D. Card, Elsevier.

Lumsdaine R., Stock, J.H., Wise D.A. (1991) "Three models of retirement: computational complexity versus predictive validity" in Topics in the Economics of Ageing: 19-60. Chicago: University of Chicago Press.

Lumsdaine R., Stock, J.H., Wise D.A. (1995) "Why Are Retirement Rates So High At Age 65?", *NBER Working Paper* n. 5190, July.

Maddala G.S. (1983) *Limited-dependent and Qualitative Variables in Econometrics,* Cambridge University Press, New York.

Madrian B. (1993) "Post-Retirement Health Insurance and the Decision to Retire", Unpublished manuscript. Graduate School of Business, University of Chicago.

Madrian B. and Beaulieu N.D. (1998) "Does Medicare Eligibility Affect Retirement?", D. Wise, ed. *Inquiries in the Economics of Agin* g: 109-131. University of Chicago Press.

Mastrobuoni G. (2000) "Public Pensions in Italy and Germany: A Comparison based on Panel Data", *Rivista di Politica Economica*, 12: 37-78.

Mastrogiacomo M. (2001) "The Dual Family Retirement in Italy", *CeRP WP*, n. 20.

Meghir C. and Whitehouse E. (1996) "The Evolution of Wages in the United Kingdom: Evidence from Micro Data", *Journal of Labor Economics* 14(1): 1-25.

Miniaci R. (1998) "Microeconometric Analysis of the Retirement Decision: Italy", *OECD Economics Department W.P.* No. 205, Paris.

Nelissen J.H.M. (1994) *Income redistribution and social security: an application of microsimulation*, Chapman & Hall, London.

OECD (1995) "The Labour Market and the Older Workers", Social Policies Studies, n. 17, Paris.

Onofri P. (1998) "Nonostante tutto, un altro pezzo di riforma del sistema pensionistico", *Politica Economica*, 14(1): 5-19.

Peracchi F. and Rossi N. (1996) "*Nonostante Tutto, è una Riforma*", in Gavazzi F., Penati A. and Tabellini G. (edited by), *Frontiere della politica economica*, Milano, Il Sole 24 Ore.

Rossi N. and Visco I. (1995) "National Saving and Social Security: Italy, 1951-1994", mimeo.

Rust J. (1989) "Behavior of male workers at the end of the life-cycle: an empirical analysis of states and controls", *Discussion Paper, Institute for Empirical Macroeconomics 6*, Federal Reserve Bank of Minneapolis.

Rust J. (1994) "Structural Estimation of Markov Decision Processes" in *Handbook of Econometrics*, vol. 4 eds. Engle R.F and McFadden D.L, North-Holland, Amsterdam: 3081-3143.

Rust J. (1997) "Using Randomization to break the Curse of Dimensionality", *Econometrica*, 63(3): 487-516.

Rust J. and Phelan C. (1997) "How Social Security and Medicare Affect Retirement Behavior in a World of Incomplete Markets", *Econometrica* 65(4): 781-831.

Samwick A. (1998) "New evidence on Pensions, Social Security, and the Timing of Retirement", NBER WP No. 6534.

Sandor Z. (2001) *Computation, Efficiency and Endogeneity in Discrete Choice Models*, Groningen: University Library Groningen.

Spataro L. (2000a) "Le scelte di pensionamento in Italia: un'applicazione (ed estensione) del modello *Option Value*", *Studi Economici, 72:* 25-54.

Spataro L. (2000b) "Analisi degli incentivi al pensionamento anticipato del sistema previdenziale italiano dopo le riforme degli anni novanta", *Studi e Ricerche*, Dipartimento di Scienze Economiche, Università di Pisa n. 66.

Spataro L. (2002a) "Social Security Incentives for Retirement in Italy", mimeo.

Spataro L. (2002b) "Social Security and Retirement Decisions in Italy", mimeo.

Stern, S. (1996) "Approximate Solutions to Stochastic Dynamic Programs", *Econometric Theory*, 13 (3): 392-405.

Stock, S.H. and Wise, D. (1990) "Pensions, the option value of work, and retirement", *Econometrica*, 58: 1151-80.

Van der Klaauw W. and Wolpin K.I. (2001) "Social Security, Pensions and the Savings and Retirement Behavior of Households", mimeo.

Vitaletti G. (2000) "Problemi e potenzialità della riforma pensionistica del 1995 in un confronto tra modelli previdenziali stilizzati", *Economia Pubblica*, n.4.

Wolpin K.I. (1996) "Public-Policy Uses of Discrete-Choice Dynamic Programming Models", *American Economic Review*, 86(2): 427-32.

Appendix 1: Figures and Tables

Figure 1. All workers: age at retirement *(source: SHIW, year 1995)*

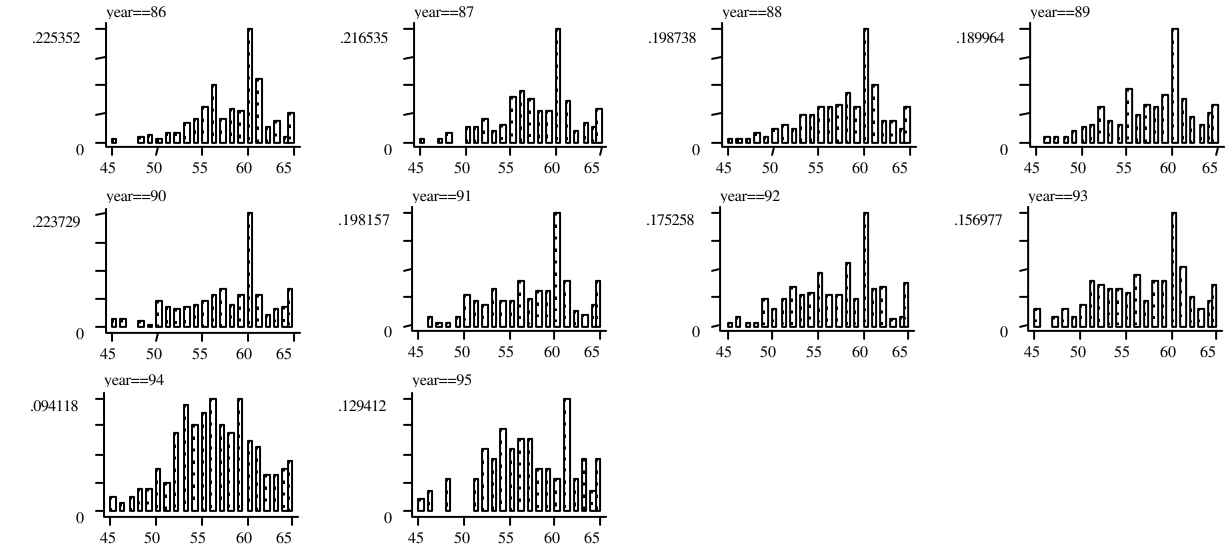

Figure 2. All workers: contributions at retirement

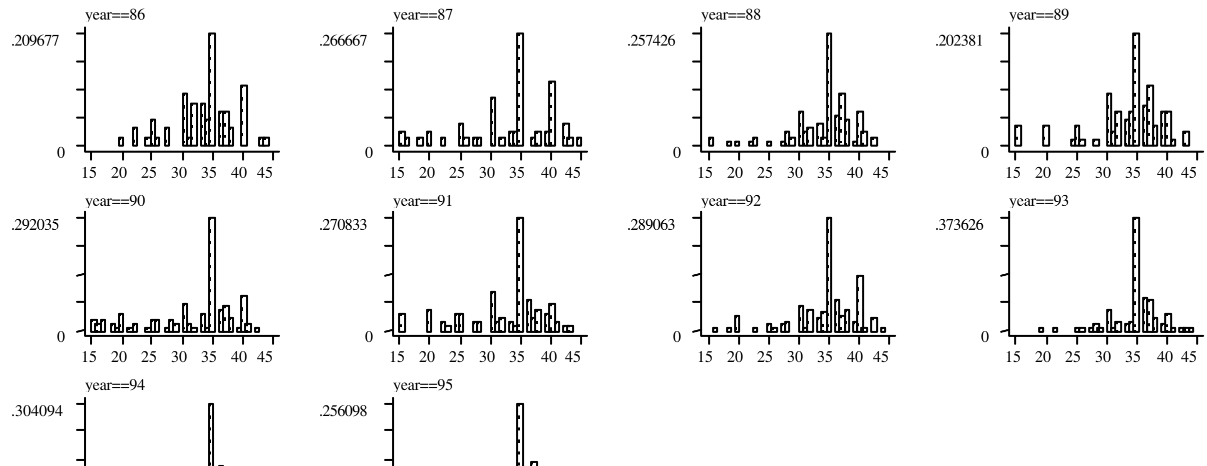

Figure 3. Private Sector employees: age at retirement

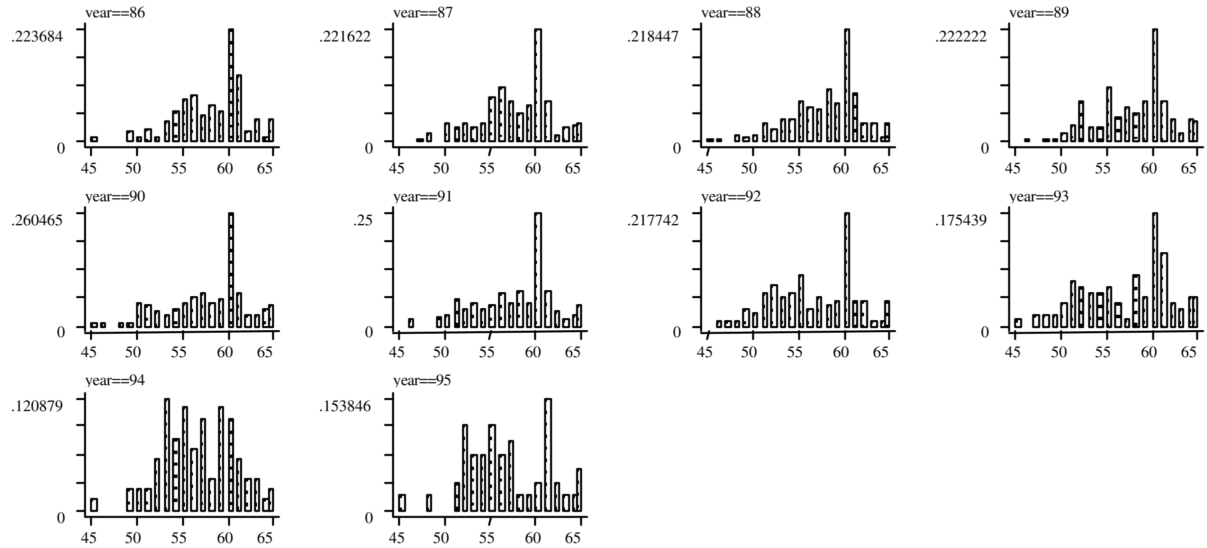

Figure 4. Private Sector employees: contributions at retirement

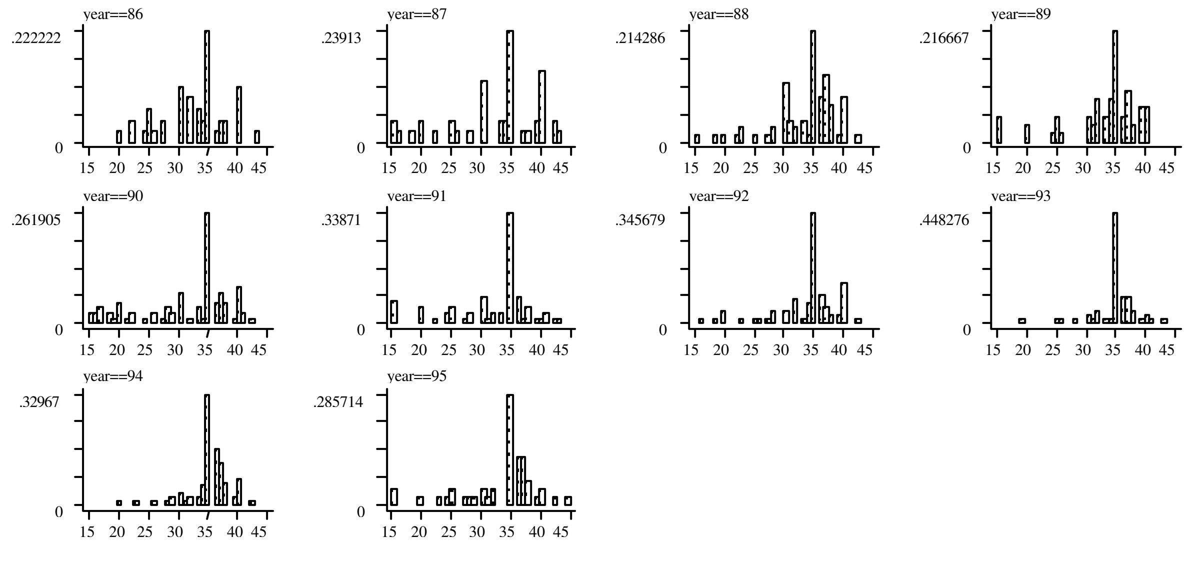

Figure 5. Public Sector employees: age at retirement

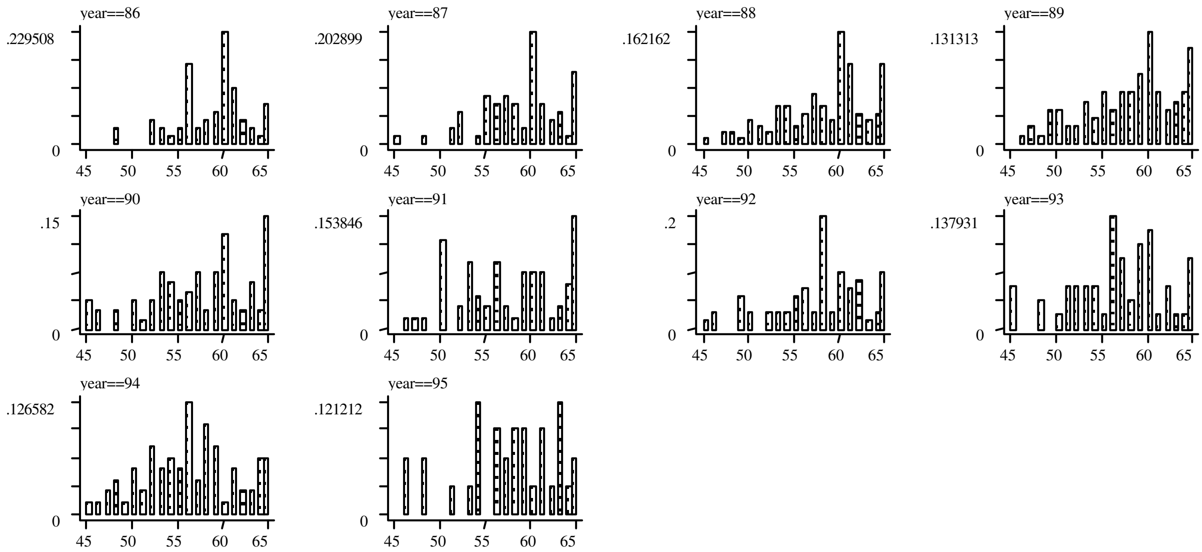

Fig. 6. Public Sector employees: contributions at retirement

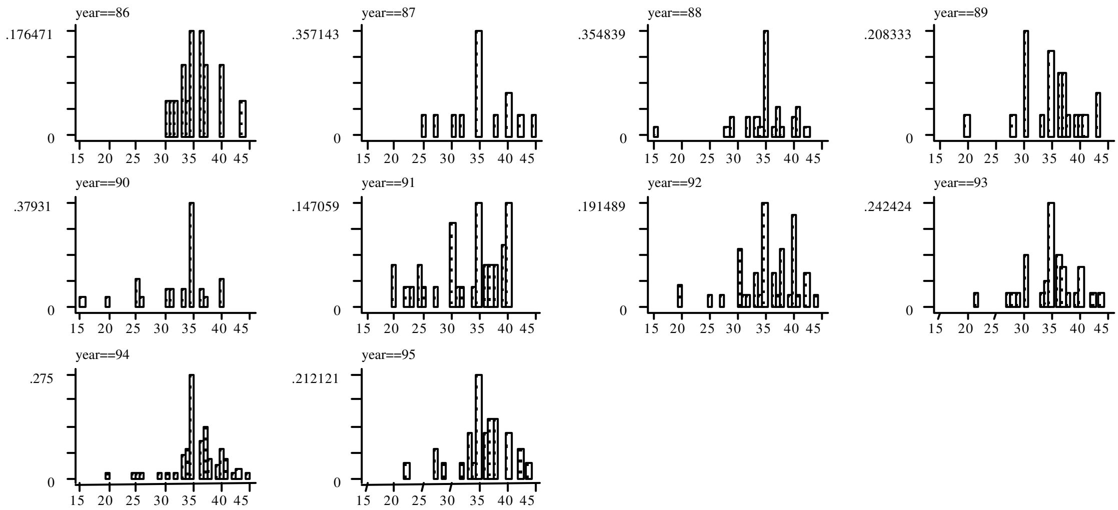

Table 1: Major features of the Social Security system prior to and after 1990s reforms*

Years	Seniority Pensions		Old age Pensions		SS payroll tax	Pensions Indexation Rate	Pension formula	Yearly interest rate (nominal)	Time span for "Pensionable earnings" computation (average of wages of the last):
	Age	Contributions	Normal Age	Contributions					
1988-1992	-	35 years (20) no more than 40	60	15	26.4	Wage growth	Defined Benefits	2% and decreasing according to wage caps (more than 2% and no caps)	5 years (approximately 1 year)
1993 (Amato Reform: transition)	-	35 and no more than 40	60	16	27.17	Price growth		2%, decreasing according to wage caps and earning brackets, +1% yearly indexation of wages entering the pensionable earnings for the part of pension maturated from 1993 to retirement date	Same as prior to reform+50% period from 1/1/93 to retirement date
1993 reform regime			65	20					Whole working life
1994	-	35 (between 21 and 35), and no more than 40	61	16					Same as 93 +50% of time between 1/1/93 and 31/1/96+66.6% of time from 1/2/96 to retirement date
1995 (Dini Reform: transition)	-	35 and less than 40	62	17	32.7		Defined Benefits (+Defined Contribution Correction for younger workers)		
1995 reform Regime	Seniority Pensions Disappear		Either 57 to 65 age and at least 35 years of contributions or 40 years of contributions and any age				Defined Contribution	Long run GDP growth rate	Whole working life

* Public Sector in parentheses, if different from Private Sector. If not specified changes in the transitional phase apply to workers who had paid contributions for at least 15 years by 1/1/1993.

* Since 1994 a penalization on retirement before 35 years of contributions was introduced: about 1.5% of pension benefit decrease for each contribution payment year missing to 35.

Table 2a: Sample for the empirical analysis

Year	Number of observations			
	Original Observations		Person-year Observations	
	Public Sector	Private Sector	Public Sector	Private Sector
88			162	162
89	158	157	158	157
90			333	335
91	334	345	334	345
92			321	328
Total	492	502	1308	1327

Table 2b. Data description. Retirement flows in Italy out of householders belonging to the labor force: 48-64 age interval (percentages in parentheses)

Year	Whole sample		Eligible individuals	
	Retired	Obs	Retired	Obs
88	34 (10.49)	324	21 (11.29)	186
89	34 (10.79)	315	29 (15.34)	189
90	55 (8.23)	668	16 (9.09)	176
91	55 (8.10)	679	51 (11.83)	431
92	58 (8.94)	649	43 (12.95)	332
93	43 (6.66)	646	30 (15.96)	188
94	76 (14.81)	513	74 (21.20)	349
95	34 (6.95)	489	26 (20.31)	128
Total	389 (9.08)	4283	290 (14.65)	1979

Table 2c. Data description: mean values (std. dev. in parentheses)

Variables	Whole sample		Eligible workers	
Retired	.0895636	(.2856097)	.1217656	(.3271394)
Age	53.60152	(4.039742)	54.5997	(4.313799)
Married	.945351	(.2273369)	.95586	(.2054844)
Age difference with the spouse	3.877419	(4.311672)	3.958904	(4.284599)
# of Family Components	3.814421	(1.186844)	3.883562	(1.208999)
# of income recipients	1.902087	(.9144787)	1.910959	(.9295775)
House owner	.7316888	(.4431646)	.7450533	(.4359972)
Wife Without income (if married)	.5912713	(4916923)	.5844749	(.493)
Public sector worker	.4963947	(.5000819)	.7884323	(.4085754)
First Eligibility Year	.0398482	(.1956396)	.0616438	(.2405991)
Within three years from eligibility	.2607211	(.4391113)	.1872146	(.3902322)
Lifetime mean gross wage*	2.834721	(1.270864)	3.020603	(1.260403)
SS Contributions paid	30.76812	(4.956045)	32.04414	(4.667582)
Regional unempl. Rates	8.602277	(5.111015)	8.876104	(5.13201)

** (1992 lira divided by 10000, and after age 47)*

Table 3. Social Security incentives: mean values (std. dev. in parentheses)*

Variables	Whole sample			Eligible workers		
	Means	Std. Dev	R^2**	Means	Std. Dev	R^2**
SS wealth	54.21946	(22.63974)	0.64	36.3879	28.35189	0.87
RR	.6808583	(.1005766)	0.41	.3395248	.3478184	0.21
Accrual	-1.560468	(3.602191)	0.08	.8622192	8.686875	0.08
Implicit Tax/subsidy	.4892252	(1.288066)	0.09	-.3200935	2.770845	0.08
RMCR	.2773677	(1.248759)	0.09	1.086874	2.7628	0.08
Peak Value	.0375138	(6.69016)	0.48	10.96632	18.3144	0.19
Option Value	7.568785	(13.89087)	0.44	23.56493	29.12833	0.42
RMCV	-1.171378	(1.677232)	0.13	-1.93471	3.215316	0.26
MTV	3.595923	(7.194539)	0.19	9.350937	18.70328	0.16

** All values are expressed in 1992 10000 lira*

***R-squared resulting from regressing the Social Security incentive over Current Earnings and Average Life Time Earnings polynomials, age dummies and Working Sector*

Table 4. Estimation Results of Proportional Hazards: static Social Security incentives (Std. Errors in parentheses)

Variables	SSW		SSW/Current Wage		RR	
P*Static SS Incentive	.027607	(.0161556)	.0709053	(.0438603)	1.300481	(0.292151)
S* Static SS Incentive	.0418654	(.0100792)	.2043334	(.0551324)	7.130168	(1.5365)
Age	2.179674	(.5920047)	1.613253	(.5816251)	1.674115	(.5720915)
Age^2	-.0171682	(.0051309)	-.0121522	(.0051046)	-.0135267	(.0049854)
Age 60* Within three years since eligibility achievement	1.90125	(.6804577)	2.015023	(.7599815)	2.185577	(.801416)
P*Average Lifetime wage	-.7302347	(.2188362)	-.4240287	(.1398476)	-.4034633	(.1371114)
S*Average Lifetime wage	-.8400011	(.210606)	-.1902994	(.0969131)	-.2316534	(.1011627)
P*Married*Age difference	-.0518442	(.0334835)	-.0546082	(.0337202)	-.0413271	(.0325367)
S*Married*Age difference	-.0448251	(.024319)	-.0504503	(.023936)	-.0488666	(.0246609)
P*# of Family Components	.0372727	(.2503802)	.0288571	(.2582436)	-.0399981	(.2424868)
S*# of Family Components	-.2247085	(.236292)	-.2365127	(.2349456)	-.1823239	(.2413958)
P*# Income Receivers	.4048646	(.2525701)	.3773536	(.2522989)	.4237202	(.2458694)
S*# Income Receivers	-1.021205	(.3021339)	-1.097919	(.312017)	-1.015096	(.3018529)
P*House ownership	.5925446	(.2786678)	.576471	(.287521)	.5661423	(.2701261)
S*House ownership	-.1313081	(.2771442)	-.0284738	(.294804)	-.0068021	(.299667)
P*Married	.783283	(.5066614)	.8342038	(.5255559)	.8349339	(.5048257)
S*Married	.7993021	(.5846272)	.7381233	(.5770882)	.608646	(.5731044)
P*Non-working wife	-.7621013	(.3136812)	-.7664538	(.3212561)	-.7205979	(.3169398)
S*Non-working wife	-.1680043	(.2615545)	-.1762662	(.2675571)	-.1558236	(.2710066)
Public Sector	-2.85939	(1.073226)	-5.400705	(1.511523)	-7.197632	(1.74426)
P*Regional unempl. rate	-.0245103	(.0308374)	-.0338702	(.0303988)	-.0135484	(.0276554)
S*Regional unemp. rate	-.0324784	(.0265973)	-.0242825	(.0269497)	-.0322208	(.0265847)
constant	-67.49128	(17.08898)	-52.16292	(16.56998)	-51.16505	(16.40119)
Log likelihood	-374		-371		-367	

P and S stand for Private and State Sector respectively

Table 5. Estimation Results of Proportional Hazards: one-year dynamic Social Security incentives (Std. Errors in parentheses)

Variables	Accrual		Tax/Subsidy		RMCR	
P*SS incentive	.1082335	(.0559135)	-.0762947	(.0640068)	.0751228	(.0646646)
S*SS incentive	.0337939	(.0347166)	-.0568862	(.1384536)	.0606898	(.1461355)
P*RR	3.746727	(2.185836)	2.48721	(1.6463)	2.444105	(1.640899)
S*RR	7.420241	(1.60588)	7.305598	(1.583164)	7.314789	(1.587702)
Age	1.739631	(.6008545)	1.779825	(.5976546)	1.778705	(.5975287)
Age^2	-.0140799	(.0052519)	-.0144877	(.0052198)	-.0144776	(.0052187)
Age 60* Within three years since eligibility achievement	2.227979	(.8054845)	2.19079	(.7946011)	2.191367	(.7951113)
P*Average Lifetime wage	-.3489618	(.128307)	-.3775121	(.1369728)	-.3785356	(.1371)
S* Average Lifetime wage	-.2046868	(.1054512)	-.2262243	(.1028908)	-.2262172	(.102848)
P*Married*Age difference	-.0328903	(.0331941)	-.0359947	(.0329392)	-.036193	(.0329493)
S*Married*Age difference	-.0465884	(.0248387)	-.0464621	(.0247663)	-.046426	(.024775)
P*# of Family Components	-.1169316	(.2570765)	-.0422601	(.2416907)	-.0420376	(.2417)
S*# of Family Components	-.1709013	(.2431513)	-.1799728	(.2426271)	-.1799998	(.2425978)
P*# Income Receivers	.416873	(.2451859)	.4181406	(.2449861)	.4181176	(.2449675)
S*# Income Receivers	-.9858444	(.3042282)	-.9913523	(.2969553)	-.9922254	(.297116)
P*House ownership	.5099169	(.2702752)	.5200223	(.2715191)	.521651	(.2716895)
S*House ownership	-.0033299	(.2964259)	-.0028368	(.2967034)	-.0029289	(.2966938)
P*Married	.9333399	(.4884194)	.9300186	(.4933458)	.9274205	(.4937196)
S*Married	.5614197	(.5873486)	.5797879	(.5758676)	.579441	(.5759512)
P*Non-working wife	-.7438556	(.329709)	-.7726647	(.3252769)	-.7710367	(.3253535)
S*Non-working wife	-.1758836	(.2704991)	-.1593878	(.2692462)	-.1595709	(.2692123)
Public Sector	-5.846973	(2.05802)	-6.394948	(1.866317)	-6.419445	(1.893011)
P*Regional unemp. Rate	-.0036306	(.028224)	-.0073885	(.028881)	-.0075616	(.0288639)
S*Regional unemp. Rate	-.0352874	(.0266032)	-.033238	(.026761)	-.0332472	(.026758)
Constant	-54.61824	(17.04024)	-54.93843	(17.14997)	-54.93354	(17.15299)
Log-likelihood	-363		-365		-365	

P and S stand for Private and State Sector respectively

RMCR stands for Rescaled MCR, that is the ratio between the MCR and the current year wage

Table 6. Estimation Results of Proportional Hazards: lifetime dynamic Social Security incentives

Variables	Peak Value		Option Value		RMCV		MTV	
P*SS incentive	.0409116	(.0391833)	-.0007615	(.0188182)	-.0435087	(.0558367)	.1235958	(.0789966)
S*SS incentive	-.0103325	(.0264771)	-.0090397	(.0152011)	-.026059	(.0934263)	.055688	(.0207815)
P*RR	2.361459	(1.680821)	1.267674	(1.546184)	1.882347	(1.503743)	3.819889	(1.486923)
S*RR	7.002836	(1.558087)	6.886266	(1.608401)	7.160928	(1.535493)	7.694602	(1.627807)
Age	1.616269	(.585359)	1.629214	(.5785778)	1.73522	(.5757815)	1.753754	(.5933096)
Age^2	-.0129983	(.0051087)	-.0131454	(.005042)	-.0140644	(.0050207)	-.014224	(.0051792)
Age 60* Within three years since eligibility achievement	2.191815	(.7988517)	2.179785	(.791222)	2.183033	(.7939784)	2.2077	(.7972438)
P*Average Lifetime wage	-.4015791	(.131411)	-.399413	(.1401523)	-.3851247	(.1385886)	-.297651	(.1441982)
S* Average Lifetime wage	-.2400222	(.1086234)	-.2216504	(.1016221)	-.2353111	(.1011503)	-.1735453	(.012729)
P* Age difference	-.0370245	(.0323674)	-.0413146	(.0323436)	-.0382359	(.0330877)	-.0336028	(.033515)
S*Age difference	-.0495155	(.0245946)	-.0492891	(.0246059)	-.0482968	(.0245308)	-.0446329	(.0251826)
P*# of Family Components	-.0945312	(.2467452)	-.0401739	(.2425054)	-.0457247	(.2435169)	-.1041475	(.2563351)
S*# of Family Components	-.1857023	(.2415141)	-.1842011	(.2412654)	-.1839831	(.2418492)	-.1570761	(.2430425)
P*# Income Receivers	.4333348	(.2492829)	.4281328	(.2466428)	.4202824	(.2459431)	.4181451	(.2446489)
S*# Income Receivers	-.9857131	(.3041078)	-1.011901	(.3012474)	-.9918102	(.3002974)	-.9835674	(.2998106)
P*House ownership	.521789	(.2685976)	.5654665	(.270285)	.5437547	(.271991)	.526842	(.2719457)
S*House ownership	-.0173164	(.300316)	-.0169246	(.3014583)	-.0127993	(.3041335)	-.0113198	(.3008533)
P*Married	.8468693	(.4980497)	.8316822	(.5037293)	.8812609	.4945474)	.9639644	(.4852321)
S*Married	.6342757	(.5715497)	.6408742	(.5726811)	.5959479	.5738207)	.5750595	(.5989733)
P*Non-working wife	-.6879211	(.3229269)	-.7165587	(.3179758)	-.7427368	(.3232272)	-.7725061	(.3312362)
S*Non-working wife	-.1501957	(.2723412)	-.1466625	(.2722898)	-.1523964	(.2711337)	-.1906913	(.2730124)
Public Sector	-6.53472	(1.855162)	-7.057826	(1.858202)	-6.684232	(1.84202)	-5.849759	(2.241088)
P*Regional unemp. rate	-.0111411	(.0271666)	-.0133156	(.0277449)	-.0096192	(.029165)	.0001309	(.0292599)
S*Regional unemp. rate	-.0317476	(.0267539)	-.0315815	(.0267464)	-.0334103	(.0270539)	-.0374339	(.0269644)
Constant	-50.17385	(16.7263)	-49.84149	(16.58402)	-53.41336	(16.57251)	-55.15313	(16.84789)
Log-likelihood	-365		-365		-366		-360	

P and S stand for Private and State Sector respectively
RMCV is the difference between the minimum future RMCR, and the current RMCR

Table 7. Option Value model estimates: results (Std. Errors in parentheses)

Model	1	2
Parameters		
$S{*}\gamma$	*0.7101 (0.2160)*	*0.5109 (0.2529)*
$S{*}\theta 1$	*1.5588 (0.3981)*	*1.5849 (0.4875)*
$S{*}\theta 2$	$=S{*}\theta 1$†	*1.7244 (0.5580)*
$S{*}\phi$	*0.8396 (0.0363)*	*0.8424 (0.0376)*
$S{*}\sigma_{\omega}(10)^{3}$	*5.1236 (7.0460)*	*4.1262 (6.2876)*
$S{*}\alpha$	*0.3555 (0.1118)*	*0.3386 0.1212)*
$P{*}\sigma_{\omega}(10)^{3}$	$=S{*}\sigma_{\omega}$ †	$=S{*}\sigma_{\omega}$ †
$P{*}\gamma$	*0.6201 (0.6046)*	*0.4392 (0.5358)*
$P{*}\theta 1$	*1.3303 (1.3638)*	*1.4964 (1.1810)*
$P{*}\theta 2$	$=P{*}\theta 1$†	*4.3070 (3.0917)*
$P{*}\phi$	*1.0688 (0.5834)*	*1.0897 (0.5095)*
$P{*}\alpha$	*0.2148 (0.1257)*	*0.2302 (0.1226)*
# of observations	1314	1314
Log. Likelihood	-440	-434

Legend

$\theta 1$ *if age* < 60, $\theta 2$ *otherwise.*

† Restriction imposed.

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