Happy Together: A Structural Model of Couples' Joint Retirement Choices

María Casanova*‡

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Abstract

Evidence from different sources shows that a significant proportion of spouses retire within less than a year from each other, independently of the age difference between them. The existing reduced-form analyses of couples' retirement suggest that this is partly due to complementarities in spouses' tastes for leisure, which are present when one or both partners enjoy retirement more if the other is retired as well. In order to accurately estimate the role of leisure complementarities, it is essential to appropriately control for incentives to joint retirement acting through the household budget constraint. This paper presents a structural, dynamic model of older couples' saving and participation decisions which allows for the complementarities in spouses' leisure and where the financial incentives and uncertainty facing spouses are carefully modeled. Couples are heterogeneous in household wealth and spouses' wages, pension claims, and health status. They face uncertainty in earnings, medical costs, and survival. The model parameters are estimated using a sample of older individuals from the Health and Retirement Study. Estimation results show that leisure complementarities are positive for both husband and wife and account for up to 8 percent of observed joint retirements. The social security spousal benefit is found to account for an extra 13 percent of them. These results imply that incentives for joint retirement play a crucial role in determining individual choices. Since these incentives cannot be captured in a model that takes one spouse's behavior as exogenous, this suggests that individual models of retirement are no longer an appropriate approximation of the average household's behavior, given the increasing number of working couples approaching retirement age.

*UCLA

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4.1 Introduction

With the first baby-boomers reaching retirement age in 2010, a massive increase in US old-age population will be taking place during the next decade. Even under the most optimistic assumptions regarding future birth rates and immigration, a sharp rise is projected in the share of GDP devoted to Social Security and Medicare.[1] Different policies have been suggested in order to alleviate the budgetary burden, some of which, such as the progressive increase of normal retirement age up to 67 years of age, are already taking place. In this context, it is crucial that we understand how savings and employment decisions respond to changes in incentives during the years around retirement age. This will allow understanding and predicting the effects of policy changes and, more importantly, measuring the effects on old age well-being.

Most existing retirement models study the behavior of individuals -usually men. Many of these studies[2] analyze retirement within the framework of a structural model. A structural approach is particularly suited to the analysis of retirement decisions, given the complex financial incentives facing workers at the end of their careers. It is hard to summarize the high nonlinearity of pension accrual with age, for instance, in a measure that can be used in a reduced-form framework. Moreover, a structural approach captures the sequential nature of work and saving decisions, which are adjusted over time following the realizations of uncertain events. Uncertainty plays an increasing role at older ages, when the incidence of negative shocks to health, out of pocket medical expenditures, and survival is much larger than when individuals are young. Finally, the estimation of structural parameters allows to carry out counterfactual policy experiments, such as forecasting the impact of changes in social security rules on the retirement choices and wellbeing of workers affected by those changes.

A crucial fact about individuals approaching retirement is that the majority of them are married. According to the Health and Retirement Study (HRS) data, 78% of men aged 55 to 64 in 1992 were married or living with a partner. Structural models of men's retirement have traditionally taken their wives' income as exogenous, and have ignored the wives' participation decision. While this may have been an appropriate approximation of reality in a time when the majority of women did not work, those strong restrictions are no longer valid. The typical household approaching retirement today is one where both husband and wife are employed. In the HRS, 70% of married men aged 55 to 64 in 1992 and 58% of their wives were working.

In the last 10 years we have seen the first structural models of couples' retirement decisions. These models acknowledge the role of both husband and wife as separate decision-making agents within the household, and represent each spouse's preferences with a separate utility function. The models of couples' retirement can be broadly divided in two groups. In the first group, models such as Blau

[1]Congressional Budget Office (CBO) "The Long-Term Budget Outlook 2009" http://www.cbo.gov/ftpdocs/102xx/doc10297/06-25-LTBO.pdf

[2]Gustmand and Steinmeier (1986), Blau (1994 and 2008), Rust and Phelan (1997), French (2005) and French and Jones (2010).

and Gilleskie (2006) and Van der Klaauw and Wolpin (2008) concentrate on carefully modeling the environment in which couples make decisions and its effect on husbands and wives' choices through the shared budget constraint. Both these papers include a detailed specification of the social security rules, the rules associated to different types of health insurance coverage, and the stochastic processes for wages, health, and survival. Van der Klaauw and Wolpin also incorporate savings with limited borrowing and unobserved heterogeneity. Accounting for the presence of both husband and wife in the household improves in several respects on previous papers that also modeled carefully the environment in which men make decisions but abstracted from their wives' role (such as Rust and Phelan (1997), French (2005) and French and Jones (2010)). On the one hand, these papers have something to say about the behavior of women, and can study how they respond to their own incentives. On the other hand, they can more accurately model the household budget constraint: because both husband and wife provide income and share household wealth, they can potentially insure each other against shocks to wages, health, or medical expenditures. A model that does not consider the presence of a working wife may overestimate the risk facing men. Moreover, the social security spousal benefit implies that men whose wife qualifies for this program can substitute their wage upon retirement for up to 150% the amount of pension they would have otherwise received. Once, again a model where the participation status of the wife is not considered may underestimate these men's incentives to retirement.

The other group of models dealing with couples' retirement stems from the observation that a significant number of spouses retire within less than a year from each other, independently of the age difference between them[3]. The study of this phenomenon, known as joint retirement, led to a series of reduced-form studies (Coile (1999) and Banks et al. (2010)) that showed that the proportion of spouses retiring together is larger than financial incentives alone can explain, and suggested the existence of complementarities in spouses' preferences. In particular, if spouses enjoy spending time together, it is possible that they derive a higher value from being retired when their partner is retired too. This complementarity in leisure would give spouses incentives to coordinate their retirement decisions.

The main structural papers that have accounted for the role of leisure complementarities are Gustman and Steinmeier (2004) and Maestas (2001). They find that complementarities are crucial to explain coordination in spouses' choices. The main drawback of these studies is that they make strong simplifying assumptions regarding the financial and stochastic environment in which individuals make retirement choices. Specifically, they assume perfect capital markets and no uncertainty. However, studies of individual retirement have suggested that the existence of credit constraints before individuals become eligible for a Social Security pension may explain the high frequency of retirement at age 62 (Rust and Phelan (1997)); and they have shown the crucial role that uncertainty regarding future income, health costs, and survival plays in determining individual retirement outcomes (Rust and Phelan (1997),

[3]Evidence of joint retirement of US couples is found in the New Beneficiary Survey (Hurd (1990a)), the National Longitudinal Survey of Mature Women (Gustman and Steinmeier (2000)), the Retirement History Study (Blau (1998)) and the Health and Retirement Study (Michaud (2003)). Banks, et al. (2010) find evidence of joint retirement of couples from the English Longitudinal Study of Ageing.

French (2005), French and Jones (2010), De Nardi et al. (2009 and 2010)). It is not clear a priori how these simplifying assumptions on the factors that determine individual retirements interact with the estimation of the complementarity parameters. In the presence of correlation of shocks across spouses, for instance, they may lead to overestimation of its magnitude.

This chapter aims to bridge the gap between the two strands of the literature on couples' retirement by estimating the effect of leisure complementarities on spouses' retirement timing within a rich dynamic model of participation and saving decisions that carefully accounts for the main financial incentives and sources of uncertainty facing older couples. The model includes a detailed specification of the social security rules, allows for limited borrowing, and accounts for uncertainty in future wage income, out of pocket medical expenditures, and survival. Each spouse's preferences are represented by their own utility function, and the substitutability between consumption and leisure is not constrained to being equal for husband and wife. Individuals within and across couples are heterogeneous in the persistent component of their wage offers, which is estimated from the data. In order to capture leisure complementarities, each spouse's utility is allowed to depend on the partner's participation status.

The model is estimated using a subsample of older individuals from the Health and Retirement Study (HRS). Estimation results show that leisure complementarities are positive and significant, and account for up to 8 percent of observed joint retirements. The social security spousal benefit is found to account for an extra 13 percent of them. These results imply that incentives for joint retirement play a crucial role in determining individual choices. Since these incentives cannot be captured in a model that takes one spouse's behavior as exogenous, this suggests that individual models of retirement are no longer an appropriate approximation of the average household's behavior, given the increasing number of working couples approaching retirement age.

The rest of the chapter is organized as follows: section 4.2 presents an overview of the main incentives to retirement facing individuals and couples, and how these are captured in the theoretical model. Section 4.3 describes the theoretical model. Section 4.4 reviews the procedure used to solve and estimate a stochastic, dynamic, Markov process with both discrete and continuous controls. Estimation results for the laws of motion of the exogenous variables are presented in section 4.5, and for the preference parameters in section 4.6. Section 4.7 concludes.

4.2 Overview

The objective of this chapter is to disentangle the role of financial incentives versus leisure complementarities in explaining joint retirements, that is, the observed tendency of spouses to retire within a short time from each other. In order to do this, I develop and estimate a structural model of couples' saving and retirement choices.

So as to accurately measure the share of joint retirements occurring in response to financial incentives, the model must replicate in a precise way the environment in which couples make participation and saving decisions. This section describes this institutional environment, which agents are assumed to take as given. It discusses the main incentives the regulatory environment gives for individuals to retire at specific ages and for couples to retire together. The section also explains how this environment leads to the choice of estimation sample.

4.2.1 Incentives to retirement from the individual perspective

One of the most important predictions of the life-cycle model is that households will accumulate assets through their working life in order to finance retirement. Given that the interest of this study is in older couples, we would expect most of them to have accumulated a significant amount of wealth by the time they are first observed, already in their fifties. Nevertheless, 55% of the couples interviewed in the first survey wave report a net value of financial wealth -which excludes housing wealth- of less than $10,000. Unless all these couples intend to use their primary residence to finance their retirement, it would seem that their savings are far too low to support them into old age. Financial savings, however, are only one of the several possible ways to finance retirement. The role of alternative sources of retirement funds, and the incentives for retirement at particular ages provided by each of them, is considered below.

Social Security

Social Security benefits represent a source of retirement income for most of the older population. In 2005, 90% of individuals aged over 65 received benefits from the Social Security, and for 65% of elderly households these benefits represented more than half their income[4].

Figure 4.3 in appendix 3.D shows the distribution of retirement ages for men and women between ages 51 and 70. The spikes in retirements at ages 62 and 65, which have been extensively documented in the literature, are noticeable for both genders. Part of the explanation for these spikes has been attributed to the Social Security rules, explained in detail in section 4.3.7 (Gustman and Steinmeier (1986), Rust and Phelan (1997), French (2005)).

The Social Security rules are carefully captured in the theoretical model in section 4.3. So as to simplify the dynamic program, however, the decision to apply for Social Security benefits is not considered explicitly. Instead, it is assumed that individuals start claiming the first year they are observed out of work after age 62. Figures 4.5 and 4.6 in appendix 3.D use the Social Security records of HRS respondents to compare the actual claiming age with the one assumed in the model. The two series are very close for men. For women, the assumed Social Security claiming date overpredicts the peak at age 62[5]. On the whole, however, the approximation seems quite reasonable.

Private Pensions

[4] Social Security Administration. "Fast Facts & Figures About Social Security, 2007" http://www.ssa.gov/policy/docs/chartbooks/fast_facts/2007/fast_facts07.pdf

[5] The discrepancy is mainly due to a significant proportion of women who start receiving benefits before the age of 62. It is possible for a non-disabled woman to claim benefits at age 60 or before in exceptional circumstances. She should be a widow who has not remarried or taking care of young children.

An important source of incentives to retirement are private pensions. In particular, defined benefit (DB) pensions give strong incentives to retirement at specific ages: after a certain number of years of service in a firm, or past the early or normal retirement ages, the rate of pension accrual is greatly reduced and can even become negative. For a large proportion of DB pension holders, these incentives are likely to dominate those provided by Social Security provisions (Lumsdaine et al. (1994)). Benefits from defined contribution (DC) pensions, on the other hand, are typically determined only by the amount of assets accumulated in the plan at the time of retirement, and they provide no specific incentives that encourage or discourage retirement at specific ages (Lumsdaine et al. (1996)). Nevertheless, most DC pensions, such as 401(k) plans or IRAs, specify an earliest withdrawal age. Withdrawing benefits from the plan before this age is strongly penalized. This may lead liquidity-constrained individuals to remain in work while their money is locked up in their DC pension plan.

Figure 4.7 in appendix 3.D shows retirement frequencies as a function of age for men with different pension types. It is clear that DB pension holders are much more likely than DC ones to retire before the Social Security incentives kick in at age 62. Moreover, part of the exit frequencies at ages 62 and 65 for individuals with a DB pension are likely to be due to their pension plan's characteristics, rather than Social Security provisions: the most common ages in the distribution of normal retirement ages for DB pension holders are 65 and 62, followed by 55, and the rest distributed between 56 and 60. The most common early retirement ages are 62 and 55 (Karoly et al. (2007)).

The tendency of DB pension holders to retire early is confirmed by table **??** in appendix 3.E, which shows descriptive statistics for men and women group by their type of pension coverage: Men who have a DB pension plan are 17 percentage points less likely than DC plan holders to be employed by the time they become entitled to Social Security benefits at age 62.

Figure 4.8 in appendix 3.D shows retirement frequencies for women, by pension type. Even though the difference is not so noticeable as for men, DB pension holders are still more likely to retire before the age of early Social Security entitlement than DC pension holders. According to table **??**, women who have a DB pension plan are 6 percentage points more likely than those who have a DC pension plan to have retired by the time they become 62.

Introducing private pension incentives into a dynamic model implies adding a sufficient number of state variables to describe pension characteristics. In the case of DB pensions, these variables would have to include the early and/or normal retirement age, a measure of job tenure, and the wage. In a model of couples such as the one presented in section 4.3, separate state variables would have to be added for men and women, and this would render the programme computationally intractable.

Ignoring the role of DB pensions, on the other hand, would disregard an important retirement incentive. Using the sample of DB pension holders to estimate a model that does not account for DB provisions would create problems in fitting the behavior of those who retire before age 60 upon reaching their plan's early retirement age -and in the absence of any health, health cost or wage shock. Moreover, the model would likely attribute to Social Security incentives the retirement exits of individuals whose

DB-plan early or normal retirement ages are 62 and 65.

In order to maintain a computationally-tractable number of state variables while still accounting for the main incentives to retirement of the individuals in the sample, I restrict the estimation sample to couples with no private pension or one or more DC plans. DC pension holdings are treated in the model as part of household wealth. While this can be a reasonable approximation for non-liquidity constrained individuals, it is possible that a minority of DC pension holders who would have otherwise retired may be obliged to remain in work until the earliest age at which their DC pension funds become available. The high participation rates of men past age 59 suggest that this is not likely to be an issue, while very few women in the sample have a substantial amount of assets in a DC plan.

A more important concern is the special tax treatment of DC plans. Most DC pension plans allow workers to defer income taxes on plan contributions until withdrawal. The tax-deferred nature of DC-plans is not accounted for in the model, which may lead to the corresponding increase in couples' willingness to save being wrongly attributed to other causes. This will be less of a problem to the extent that the incentives to save in a 401(k) crowd out rather than build on top of other types of savings.

Couples with no private pension and those where one or both of the spouses have a DC pension are considered together in the estimation sample in order to attain a reasonable sample size. It is important, though, to bear in mind that individuals who have no private pension have quite different characteristics from those with a DC plan. Table **??** in appendix 3.E shows that they tend to belong to poorer households, have worse health, less education and lower wages. The key assumption that allows to model these two groups together is that none of them face incentives from a pension plan to retire at particular ages. The model in section 4.3 is rich enough to account for other observable and unobservable differences between the two: differences in health, wages and household wealth are captured through the initial conditions for these variables. Part of the effect of education and unobservable characteristics such as ability is captured through the initial draw for the wage error term and the initial value of wealth.

Health Insurance

A source of incentives to retirement often considered in the literature is the type of health insurance coverage. Gustman and Steinmeier (1994), Rust and Phelan (1997), Blau and Gilleskie (2006), French and Jones (2010), and Van der Klaauw and Wolpin (2008) distinguish three types of individuals according to the type of health insurance coverage: those whose health insurance is tied to their job, and would lose their coverage if they retired -i.e. individuals with "tied" coverage-; those who can keep their health insurance even if they retire from their job before age 65 -individuals with "retiree" coverage-; and those with no work-related health insurance. They argue that individuals with tied coverage will have stronger incentives to remain in work until they become eligible for government-provided Medicare coverage at 65 than those with retiree or no coverage. Gustman and Steinmeier and Blau and Gilleskie find that the effect of health insurance on retirement behavior is small. Rust and Phelan find that the effect is large for the subsample of individuals without a private pension. However, their model ignores the role of savings as insurance against medical shocks, and is thus likely to overestimate the importance of health insurance. Finally, French and Jones estimate a dynamic model with savings and participation decisions using the HRS data and find that individuals whose health insurance is tied to the job leave the labor force on average half a year later than workers with retiree coverage.

None of these studies models explicitly the relationship between health insurance and pension type. However, it can be seen from table **??** that there is a correlation between the two: individuals with no pension are the most likely to have no health insurance; individuals with a DB pension plan are the most likely to have retiree coverage; and individuals with DC pension plans are the most likely to have tied coverage. In their paper, French and Jones acknowledge this correlation, but do not control separately for health insurance and pension type. Instead, given that people with retiree coverage are the most likely to have a DB plan, French and Jones assign to them the sharpest drops in pension accrual after age 59. In this way, they compound the effect of health insurance and pension type, and thus it is not clear what part of the later retirements of people with tied coverage is due to the type of health insurance, and what part is due to them being more likely to have a DC pension (which offers no incentives for early retirement, unlike the usual DB plan).

In the absence of a model that explicitly accounts for pension type, I choose not to control for health insurance type either. I therefore ignore any incentives that individuals with tied coverage may have to remain in work for longer than the rest. The estimate of French and Jones that those with retiree coverage and a DB pension retire half a year earlier than those with tied coverage and a DC pension is likely to be an upper bound on the effect of health insurance for individuals in my estimation sample, given that I drop all observations with a DB pension plan.

4.2.2 Incentives to retirement from the couple's perspective

A growing share of the retirement literature characterizes retirement as a decision concerning the couple, rather than the individual (Gustman and Steinmeier(2004), Blau and Gilleskie (2004), Coile (2004a, 2004b), Michaud (2003), Michaud and Vermeulen (2004)). This follows the observation that a significant share of spouses retire within less than one year of each other, independently of the age difference between them. Evidence of this phenomenon, known as joint retirement, has been found in surveys dealing with couples from several generations and countries, such as the New Beneficiary Survey (Hurd (1990a)), the National Longitudinal Survey of Mature Women (Gustman and Steinmeier (2000)), the Retirement History Study (Blau (1998)), the Health and Retirement Study (Michaud (2003)), and the English Longitudinal Study of Ageing (Banks, Blundell and Casanova (2007)).

Figure 7 shows the distribution of differences in retirement dates[6] for HRS couples whose members have retired by the year 2006. The sample used to draw each graph is selected according to the age

[6]The difference in retirement dates is defined as the husband's retirement date minus the wife's retirement date. Hence positive values indicate that the husband retired at a later calendar date than the wife.

difference between spouses.[7] The first graph shows the distribution of retirement date differences for couples where the husband is at least one year younger than the wife; the second graph shows couples where the husband is the same age as the wife; and so on. In all of the 6 graphs, the highest frequency corresponds to a retirement date difference of zero, that is, to spouses retiring on the same calendar year.

There are two main channels that link spouses' retirement decisions.[8] The first one operates through the household budget constraint, and the second one comes directly from the preferences. The fact that spouses share resources through the household budget constraint can sometimes increase but also decrease the distance between their retirements. Consider, for instance, a couple of the same age where the husband intends to retire at age 65 and the wife intends to retire at age 62. A negative shock to the husband's wage the year his wife becomes 62 may lead her to keep working for one more year in order to compensate the decrease in total household income. This would result in both spouses retiring closer together. For a similar couple, the wife's retirement at 62, with the corresponding replacement of her wage by a (in almost every case) lower pension, would have an income effect on the husband, who may decide to work for one more year -hence increasing the distance between their retirement dates.

The Social Security rules offer some further cross-spouse incentives that also operate through the budget constraint. The Social Security spousal benefit establishes that the spouse with lower lifetime earnings -usually the wife- is entitled to the highest between her own pension and (up to) one half of her husband's full pension once both of them are retired. This increases the incentives to retirement for men whose wife qualifies for the benefit, as they will be replacing their wage with a pension that can be up to 50% higher than it would have been in the absence of the benefit. Since most wives with low accumulated earnings -and therefore a small amount of work experience- usually retire much earlier than their husband, the spousal benefit is likely to be one of the channels leading spouses to retire close to each other.

The second channel linking retirement decisions operates through the spouses' preferences: it is possible that husband and wife enjoy spending time together, which would mean that each one of them derives utility from sharing their retirement with their partner.

This chapter attempts to estimate the effect of leisure complementarities after appropriately controlling for the effects of financial incentives and uncertainty. The chapter bridges the gap between two strands of the couples' retirement literature: the one that focuses on accurately modeling the budget

[7] Age difference is defined as age of the husband minus age of the wife.

[8] A third potential cause of joint retirement that has been proposed in the literature is a correlation in spouses' unobserved taste for leisure. This correlation would increase the number of joint retirements in couples where husband and wife are the same age. In those cases, sharing a preference for early retirement would likely lead both husband and wife to stop working as soon as the option becomes financially viable -usually when qualifying for Social Security benefits at age 62. However, the effect of this correlation would not necessarily increase joint retirements of couples of different ages. If the husband is, say, 5 years older than the wife, and both of them want to retire as soon as it becomes financially affordable, the fact that he is eligible for Social Security benefits 5 years before his wife would likely lead to him retiring earlier than her. While it is unlikely that varying unobserved tastes for leisure play a large role in determining joint retirement, they likely remain a determinant of individual retirement timing.

constraint and stochastic processes (Blau and Gilleskie (2006), Van der Klaauw and Wolpin (2008)) and the one that underlines the role of complementarities in leisure (Gustman and Steinmeier (2004), Maestas (2001)). The empirical results allow to compare the relative role of incentives that operate mainly through the budget constraint versus leisure complementarities as determinants of the large number of joint retirement observed in the data.

4.3 Theoretical Model

This section describes a dynamic stochastic model of labor supply and saving choices of households close to retirement age. Each household consists of two spouses ("husband" and "wife") with their own preferences. The model captures the sequential nature of the decision-making process, with households adjusting their behavior in every period as the uncertainty regarding spouses' wages, survival and medical expenditures unfolds.

At each discrete period t, given initial assets and husband and wife's wages and average lifetime earnings[9], households choose optimal consumption and spouses' participation status in order to maximize the expected discounted value of remaining lifetime utility.

Retirement status is defined as a function of the participation decision: a spouse who chooses not to participate in a period when he is above the social security early retirement age (ERA) is referred to as "retired". Retirement is not an absorbing state, as retired individuals can go back to work in any future period. Spouses' decisions to apply for social security benefits are not modeled separately from the participation decision. Individuals are assumed to start receiving social security pension benefits the first period in which they choose not to work after ERA. Benefit claiming is an absorbing state: social security entitlement is determined the first time individuals claim benefits, and it is not possible for them to accrue more pension in future periods, even if they go back to work.

The agents in the model are married couples who stay married until one or both spouses die. Decisions of widowed individuals are not explicitly modeled.

4.3.1 Choice Set

At each discrete period t, households make both discrete choices -both spouses' participation status- and continuous ones -household consumption and savings.

It is useful to formalize the model explicitly separating continuous and discrete choices assuming, without loss of generality, that households make decisions in two steps: first, they make the discrete choices, that is, whether each of the spouses will work full time, part time or not at all. Then, they choose optimal household savings *conditional* on the discrete alternative.

Both types of choices are described in detail below. For ease of exposition, I will talk about the "husband" or "wife"'s choices when referring to household decisions concerning one of the spouses'

[9] Average lifetime earnings is the main variable used to determine pension entitlement at retirement.

variables, such as his or her hours of work. However, all decisions are made by the household, which acts as a sole individual who maximizes a unique welfare function.

Discrete choices

The discrete choice variables are each spouse's participation. As mentioned above, non-participation is not an absorbing state, and individuals can always go back to work after periods of inactivity. Therefore, the variables indicating participation status, P_t^i, can take on the values FT, PT or R in all periods:

$$\begin{cases} P_t^j = FT & \text{if spouse } j \text{ works full time in period } t \\ P_t^j = PT & \text{if spouse } j \text{ works part time in period } t \\ P_t^j = R & \text{if spouse } j \text{ does not work in period } t \end{cases}$$

where the superscript $j = m, f$ identifies the spouse, m being the husband or "male", and f being the wife or "female".

$\mathcal{D}^j$ is the set of discrete alternatives available to spouse j each period. It is defined as:

$$\mathcal{D}^j = \{PT, FT, R\}, \qquad \text{for } j = m, f,$$

The set of 9 discrete alternatives available to the household each period is $\mathcal{D} = \mathcal{D}^m \times \mathcal{D}^f$. Elements of $\mathcal{D}$ are of the type $d = (d^m, d^f)$, where d^m refers to the husband's participation status, and d^f to the wife's. For example, $d_t = (PT, R)$ indicates that the husband works part time and the wife does not work in period t.

Continuous choices

In each period t, households optimally choose savings, s_t, conditional on the discrete action d_t.

$\mathcal{C}_t$ is the choice set for the continuous control conditional on the discrete alternative d_t and the state spaces z_t and ε_t (described in section 4.3.2 below):

$$s_t \in \mathcal{C}_t(z_t, \varepsilon_t; d_t) \subset R_+$$

4.3.2 State Space

The state space in period t consists of variables that are observed both by the agent and the econometrician, and variables that are observed by the agent, but not by the econometrician. The vector of observed state variables is the following:

$$z_t = \{A_t, E_t^m, E_t^f, w_t^m, w_t^f, B_{t-1}^m, B_{t-1}^f, age_t^m, age_t^f\},$$

where A_t are household assets at the beginning of period t, E_t^j is a measure of spouse j's lifetime accumulated earnings, w_t^j is spouse j's hourly wage, B_{t-1}^j an indicator of whether spouse j has started claiming benefits before period t and age_t^j is spouse j's age in years.

The unobserved state variables are a vector of utility shocks associated to the discrete alternative chosen by the household:

$$\varepsilon_t = \{\varepsilon_t(d_t)|d_t \in \mathcal{D}\},$$

where $\varepsilon_t(d_t)$ affects the utility derived from alternative d at time t. The value of the vector ε_t is known by the agent when making decisions in period t.

4.3.3 Preferences

Household utility in period t is defined as the weighted sum of each spouse's utility plus an unobserved component, $\varepsilon_t(d_t)$, associated to the discrete choice and assumed known by the household:

$$U(d_t, s_t, z_t, \varepsilon_t, \theta_1) = \phi\; u^m(c_t, l_t^m) + (1-\phi)u^f(c_t, l_t^f) + \varepsilon_t(d_t), \tag{4.3.1}$$

where ϕ represents some household sharing rule assumed constant in time and θ_1 is the vector of preference parameters.

Within-period utility for each spouse, u^j, is assumed non-decreasing and twice differentiable in consumption, c_t, and own leisure, l_t^j. In the empirical part of the chapter, the function u^j is assumed to take the following form:

$$u^j\left(c_t, l_t^j; z_t, \theta_1\right) = \frac{1}{1-\rho}\left(c_t(d_t)^{\alpha_1^j} l_t^j(d_t)^{(1-\alpha_1^j)}\right)^{(1-\rho)},$$

where ρ is the coefficient of relative risk aversion and α_1^j determines the share of consumption in spouse j's utility function.

Individual leisure, l_t^j, is given by:

$$l_t^j = L - h^j(d_t^j) + \alpha_2 I\{d_t^j = R, d_t^k = R\}, \quad \text{for } j \neq k,$$

where L is the leisure endowment and h^j the number of work hours associated to participation status d_t^j (see section 4.5.1). The indicator function multiplying the coefficient α_2 is equal to 1 when both spouses are out of work. This term is intended to capture the type of leisure complementarities found by Coile (2004a) and Banks et al. (2010), whereby spouses enjoy their retirement more when their partner is retired too. A positive (negative) α_2 will provide evidence of complementarity (substitutability) in spouses' leisure.

4.3.4 Budget Constraint

Households receive income from different sources: asset income, rA_t; husband's labor income, $w_t^m h_t^m$; wife's labor income, $w_t^f h_t^f$; husband and wife's social security benefits, ssb_t^m and ssb_t^f; and government transfers T_t. Post-tax resources are allocated between household consumption, c_t, and savings, s_t. The budget constraint can be written as:

$$c_t + s_t = A_t + Y(rA_t,\ w_t^m h_t^m,\ w_t^f h_t^f,\ \tau) + B_t^m \times ssb_t^m + B_t^w \times ssb_t^f + T_t, \tag{4.3.2}$$

where Y is the level of post-tax income, r is the interest rate, τ is the tax structure, w_t denotes the hourly wage rate (described in section 4.3.5), ssb_t denotes Social Security benefits (described in section 4.3.7), and T_t are government transfers (described below).

Next period's assets are determined by subtracting out-of-pocket medical, hc_t, from household assets. Hence the asset accumulation equation is:

$$A_{t+1} = s_t - hc_t, \tag{4.3.3}$$

Households cannot borrow against future labor of Social Security income. This is reflected in the following borrowing constraint:

$$s_t \geq 0$$

The borrowing constraint implies that the household net worth at the beginning of a period can be negative if the realization of health costs exceed savings[10].

Following Hubbard et al. (1995), government transfers are parameterized as:

$$T_t = \min\Big\{c_{\min},\ \max\{0,\ c_{\min} - (A_t + Y_t + ssb_t^m + ssb_t^f)\}\Big\}$$

Transfer payments guarantee a minimum amount of resources for the household in every period equal to $c_{\min}$. The transfer function captures the penalty on saving behavior that means-tested programmes such as Medicaid, Supplemental Security Income (SSI) or food stamps impose on low-asset households.

4.3.5 Wage Process

The logarithm of the hourly wage for individual i at time t, $\ln w_{it}$,[11] is a function of a time-invariant individual component, age, participation status, and a persistent error component υ_{it}:

$$\ln w_{it} = f_i + W(age_{it}) + \varsigma I\{d_{it} = PT\} + \upsilon_{it}, \tag{4.3.4}$$

[10] French and Jones (2010) argue this is a reasonable assumption in view of the number of HRS households who report medical expense debt.

[11] Separate wage processes are estimated for men and women. To simplify notation, however, I omit the subscript j in what follows.

where the parameter ς captures the wage penalty associated to working part time. υ_{it} evolves as a random walk with a drift that depends on the participation status and a normally distributed innovation ζ_{it}:

$$\upsilon_{it} = \upsilon_{it-1} + \delta_{PT} I\{d_{it} = \text{PT}\} + \delta_R I\{d_{it} = \text{R}\} + \zeta_{it}$$
$$\zeta_{it} \sim N(0, \sigma_\zeta^2)$$

The parameters δ_{PT} and δ_R capture the permanent wage depreciation associated to every year spent in semi-retirement (i.e. working part-time) or full retirement.

Involuntary unemployment is not considered, that is, in each period every individual receives a wage offer given by 4.3.4. In this context, shocks to wages can be interpreted as shocks to productivity.

4.3.6 Health Costs

Health costs, hc_t, are defined as out of pocket costs. The main features characterizing the distribution of health costs are a high probability of very small expenditures and a long right tail. I model the conditional expectation of health costs given spouses' ages as follows:

$$E(hc_t | age_t^m, age_t^f) = E(hc_t | age_t^m, age_t^f hc_t > 0) P(hc_t > 0 | age_t^m, age_t^f), \tag{4.3.5}$$

The conditional distribution of positive health costs is assumed to be log normal:

$$\ln hc_t = h(age_t^m, age_t^f) + \psi_t, \tag{4.3.6}$$
$$\psi \sim N(0, \sigma_\psi^2)$$

4.3.7 Social Security Benefits

The Social Security system provides disincentives to work past certain ages. The strength of the incentives can be a function of household characteristics -such as as wealth or the relative level of lifetime earnings between husband and wife-, as discussed below.

The level of Social Security benefits, ssb_t, is determined from a worker's lifetime earnings in several steps.[12] First, annual earnings are indexed to account for changes in the national average wage, and the 35 highest years of earnings are used to compute the average indexed monthly earnings (AIME). Appendix 3.B describes the computation of the variable E_t, which approximates AIME.

[12] This section describes the Social Security rules that were in place in the year 1992. See the *Annual Statistical Supplement to the Social Security Bulletin* for subsequent years for information on changes to these rules.

Second, a formula is applied to AIME to obtain the primary insurance amount (PIA). This formula is weighed in favor of relatively low earners, so that the replacement rate falls as the level of earnings rises.

Third, the PIA is adjusted according to the worker's age when claiming benefits for the first time. Individuals claiming at age 65 receive the full PIA. For every year between ages 65 and 70 that benefit application is delayed, future benefits rise by the equivalent to 5.5% per year. This rate is less than actuarially fair, and therefore generates an incentive to draw benefits by age 65. For every year before age 65 the individual applies for benefits, these are reduced by 6.7%, which is roughly actuarially fair. Individuals are ineligible to receive a Social Security pension before age 62. This gives individuals with low wealth an incentive to remain in work until that age.

Once a worker has claimed benefits, these will be paid for life. Benefits are adjusted every year for increases in the CPI.

Individuals who claim benefits and keep working are subject to the Social Security earnings test. If the labor income of a beneficiary below age 65 exceeds a threshold level of $7,440, benefits are taxed at a 50% rate. For beneficiaries aged between 66 and 70 who earn more than $10,200, benefits are taxed at a 33% rate. For every year of benefits taxed away, future benefits are increased by 6.7% for workers aged between 62 and 65 and by 4% for those aged from 65 to 70. Again, this is far from actuarially fair, and hence a further disincentive to work beyond age 65.

An important feature of the Social Security program is the structure of dependent benefits. Spouses are entitled to a benefit equal to up to one half of their partner's PIA (reduced if either the worker or the spouse claims benefits before 65) if this is higher than the benefit they would get based on their own record. The spousal benefit only becomes available once the spouse reaches age 62 and the worker has claimed benefits. The majority of spousal benefit beneficiaries are women. The rule may give some men incentives to bring forward their claiming date in order to provide their wife with a pension once she becomes 62, leading to correlations in spouses' retirement decisions. Finally, widows or widowers are entitled to a benefit equal to the deceased spouse's PIA (reduced if either the worker or the deceased spouse claimed benefits before age 65), whenever this is higher than the benefit they would get based on their own record.

The formulae used to approximate Social Security benefits in the model, which take into account the features of the system just outlined, are described in detail in appendix 3.B.

4.3.8 Survival Probabilities

Survival rates are a function of age and sex. In particular, the probability that an individual who is alive in period t survives to period $t+1$ is:

$$s_{t+1}^{j} = s(age^{j}, j), \quad j \in \{\text{m,f}\}$$

4.3.9 Terminal Value Functions and Bequest Function

Upon death of one spouse, the behavior of the surviving partner is not modeled. Their remaining lifetime utility is represented by the terminal value functions B^f or B^m -depending on whether the wife or the husband survives:

$$B^j(z_t) = \theta_j \frac{(W_t^j)^{\alpha_1(1-\rho)}}{(1-\rho)} \qquad j = m, f,$$

where W is the present discounted value of retirement wealth for the surviving spouse, computed as the sum of assets available upon the death of the spouse plus the present discounted value of the surviving spouse's Social Security benefit, which are equal to the highest between their own benefits and those of the deceased partner:

$$W_t^j = A_t + PDV_t(max(ssb_t^j, ssb_t^k)) \qquad j,k = m,f, \text{ and } j \neq k$$

If none of the spouses reaches period t alive, the household derives utility from assets bequeathed to survivors, A_t. The bequest function has the following form:

$$B^b(A_t) = \theta_b \frac{(A_t + K)^{\alpha_1(1-\rho)}}{(1-\rho)},$$

where K measures the curvature of the function. $K = 0$ implies an infinite disutility of leaving non-positive bequests, while for $K > 0$ the utility of a zero bequest is finite.

4.4 Model Solution

The objective of the paper is to use the observed realizations of household choices and states, $\{d_t, s_t, z_t\}$, to estimate the vector of unknown parameters $\theta = (\theta_1, \theta_2, \theta_3)$, which includes preference parameters, θ_1, and the parameters that determine the data generating process for the state variables, (θ_2, θ_3).

It follows from the description in section 4.3 of the laws of motion for the state variables that households' beliefs about uncertain future states can be represented by a first-order Markov probability density function. There is an extensive literature dealing with the solution and estimation of stochastic Markov programs, but both the theoretical work and subsequent applications focus on discrete decision processes.[13] As the model described in the previous sections features both discrete (participation status) and continuous (savings) decisions, below I show how the solution procedure for discrete Markov processes introduced by Rust (1987, 1988) can be extended to account for the continuous control.

[13]see Eckstein and Wolpin (1989), Rust (1994), Miller (1997) and Aguirregabiria and Mira (2010) for surveys on the estimation of dynamic discrete choice models and Rust and Phelan (1997), Hotz and Miller (1993), Keane and Wolpin (1997) and Gilleskie (1998) for applications with discrete choice sets.

4.4.1 Optimization Problem

In order to solve the finite-horizon Markovian decision problem, households choose a sequence of decision rules $\Pi = \{\pi_0, \pi_1, ..., \pi_T\}$, where $\pi_t(z_t, \varepsilon_t) = (d_t, s_t)$, to maximize expected discounted utility over the lifetime. The value function is defined as[14]:

$$V_t(z_t, \varepsilon_t, \theta) = \sup_{\Pi} E \left\{ \sum_{j=t}^{T} \beta^{j-t} \left[U(d_t, s_t, z_t, \varepsilon_t, \theta_1) \right] \mid z_t, \varepsilon_t, \theta_2, \theta_3 \right\}, \tag{4.4.1}$$

where the expectation is taken with respect to the controlled stochastic process $\{z_t, \varepsilon_t\}$, with probability distribution given by:

$$f(z_{t+1}, \varepsilon_{t+1} | z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) \tag{4.4.2}$$

Since this is a finite horizon problem, the feasible set of household choices is compact, and the utility function continuous, the value function $V_t(z_t, \varepsilon_t, \theta_1)$ defined in 4.4.1 always exists and is the unique solution to the Bellman equation given by:

$$V_t(z_t, \varepsilon_t, \theta) = \max_{d_t, s_t} \left[U(d_t, s_t, z_t, \varepsilon_t, \theta_1) + \beta E V_{t+1}(z_{t+1}, \varepsilon_{t+1}, d_t, s_t, \theta) \right], \tag{4.4.3}$$

where

$$EV_{t+1}(z_{t+1}, \varepsilon_{t+1}, d_t, s_t, \theta) = \int_y \int_\eta V_{t+1}(y, \eta) f(dy, d\eta | z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) \tag{4.4.4}$$

Solving for the optimal controls d_t and s_t in 4.4.3 requires solving a highly-dimensional problem. The presence of ε_t as a state variable adds 9 dimensions to the state space, and since it enters nonlinearly the function EV_{t+1}, 9-dimensional integrals need to be solved to integrate it out. The following assumption, which is key in the framework developed by Rust (1988) for the solution and estimation of discrete Markov processes, simplifies the solution of the household problem considerably[15]:

Conditional Independence Assumption (CI): The conditional probability density function for the state variables factors as

$$f(z_{t+1}, \varepsilon_{t+1} | z_t, \varepsilon_t, d_t, s_t, \theta_2, \theta_3) = q(\varepsilon_{t+1} | z_{t+1}, \theta_2) g(z_{t+1} | z_t, d_t, s_t, \theta_3)$$

CI implies two restrictions on the serial dependence of observable and unobservable states. First, z_{t+1} is a sufficient statistic for ε_{t+1}, which implies that any statistical dependence between ε_t and ε_{t+1} is transmitted entirely through the vector of observed states z_{t+1}. Second, the probability density of z_{t+1} depends only on z_t and not on ε_t.

[14]For ease of exposition, the survival probabilities of both spouses are set equal to 1 in the description of the model solution.

[15]The CI assumption has been widely used in the literature. See Rust (1994) and Aguirregabiria and Mira (2010) for a review.

Next, I make an assumption on the functional form of the density of ε. In particular, $q(\varepsilon|z, \theta_2)$ is a multivariate extreme value distribution:

$$q(\varepsilon|z, \theta_2) = \prod_{k \in \mathcal{D}} \exp\{-\varepsilon(k) + \theta_2\} \exp\{-\exp\{-\varepsilon(k) + \theta_2\}\},$$

where $\theta_2 = \gamma = 0.577216$ is Euler's constant.

Under the CI assumption and the extreme value distribution assumption, the integral EV_{t+1} with respect to ε_{t+1} has a closed-form solution. This eliminates the need to evaluate the 9-dimensional integrals numerically, and hence renders the problem computationally tractable. In what follows I drop ε_{t+1} from the conditioning set for EV_{t+1} to indicate that it has been integrated out using the functional form restrictions.

Substituting for the specification of the utility function given in 4.3.1 the Bellman equation can be re-written as a two-stage problem:

$$V_t(z_t, \varepsilon_t, \theta) = \max_{d_t} \left[\max_{s_t} \left[u(k, s_t, z_t, \theta_1) + \beta EV_{t+1}(z_{t+1}, k, s_t, \theta) | d_t = k \right] + \varepsilon_t(d_t) \right], \tag{4.4.5}$$

where $u(d_t, s_t, z_t, \theta_1) \equiv \phi\ u^m(c_t, l_t^m) + (1 - \phi) u^f(c_t, l_t^f)$. Proceeding backwards, the solution for the optimal controls d_t and s_t can be computed in two stages: first, optimal savings are computed *conditional* on each discrete participation choice (inner maximization). Second, the discrete option that yields the highest value given the draw of the unobservable state is chosen by the household (outer maximization).

The solution of the inner maximization yields the vector of choice-specific value functions $r(z_t, \theta) \equiv \{r(z_t, k, \theta) \mid k \in \mathcal{D}\}$, where $r(z_t, k, \theta)$ represents the indirect utility function associated to the household participation status k:

$$r(z_t, k, \theta) = \max_{s_t} \{[u(k, s_t, z_t, \theta_1) + \beta EV_{t+1}(z_{t+1}, k, s_t, \theta)] \mid d_t = k\} \tag{4.4.6}$$

The outer maximization is a random utility model:

$$\max_{d_t} \{r(z_t, d_t, \theta) + \varepsilon_t(d_t)\} \tag{4.4.7}$$

As discussed in Rust (1987), 4.4.7 differs from the static random utility model (McFadden (1973, 1981)) through the addition of the term $EV_{t+1}(z_{t+1}, k, s_t, \theta)$ to the static utility $u(k, s_t, z_t, \theta_1)$ in the choice-specific value functions (4.4.6). The presence of the continuous control s_t adds a discrete-choice-specific maximization to Rust's framework.

Under the assumption that ε follows an extreme value distribution, the conditional choice probabilities are given by the multinomial logit formula:

$$P(k|z_t,\theta) = \frac{\exp\{r(z_t,k,\theta)\}}{\sum\limits_{k\in\mathcal{D}} \exp\{r(z_t,k,\theta)\}} \tag{4.4.8}$$

The parameters of the model are estimated by matching moments based on the choice-specific probabilities in 4.4.8 simulated from the structural model to those observed in the data.

4.5 Data and First Stage Results

4.5.1 Data

For the estimation of the model, I use data from the Health and Retirement Study (HRS) for the years 1992 to 2008. The HRS is a longitudinal data set representative of non-institutionalized individuals over the age of 50 and their spouses. It provides extensive information on economic status -including comprehensive measures of wealth, income from work, private pensions, social security and other government transfers-; health; retirement; and demographics.

The HRS survey data can be matched to Social Security Administration (SSA) data for those respondents who gave permission to access their administrative records. I use the restricted SSA administrative data to obtain the measure of accumulated earnings used in the model, which serves to define the amount of social security pension accrued by an individual at every point in time.

The HRS contains information on 11,114 couples. Of those, I drop 1,231 couples who either marry or divorce during the sample period and 640 couples where at least one spouse receives social security disability insurance before age 62[16]. I also exclude the extremely wealthy from the sample, dropping 102 couples with more than $1,250,000 in assets (1992 dollars).

The theoretical model presented in section 4.3 covers the main incentives for retirement of couples who do not have defined benefit pensions. For the estimation I use only couples where neither the husband nor the wife have a defined benefit pension. This reduces the sample to 6,243 couples.

When working with couples, rather than individuals, the age difference between the spouses becomes a crucial state variable. This is because couples where the husband is, say, a year older than the wife, solve a different optimization problem -in particular, they face a different intertemporal budget constraint- than couples where the husband is more or less than a year older; younger; or the same age as his wife. In the data I observe couples that are up to 30 years apart in age. In order to have a homogeneous sample, in my analysis I select only those spouses who are at most 10 years apart in age. This leaves a final sample of 5,633 couples and 32,448 couple-year observations. This sample is used to estimate the participation profiles, retirement and joint retirement frequencies, and asset profiles.

Due to computational limitations, I cannot solve and simulate the theoretical model for the whole

[16] Modelling the processes of marriage formation, divorce, and disability benefit determination is beyond the scope of this chapter. See Bergstrom (1997) and Weiss (1997) for a survey of the literature on household formation and dissolution and Buchinsky et al. (1999) for a review of the social security disability award process.

distribution of age differences used in the estimation of profiles, i.e. from -10 to +10 years. Hence, for the estimation of the preference parameters I limit the sample to couples husband is from 0 to 5 years older than his wife. There are 3,595 such couples, that is, 64% of couples in my final sample are included within this range of age differences.

Wages are computed as annual earnings divided by hours, and are dropped if wages are less than $3 per hour or greater than $100 per hour in 1992 dollars. Individuals are defined as working full time if they work more than 32 hours per week and as working part time if they work between 6 and 32 hours per week. In the solution of the theoretical model, individuals working full time are assigned the median number of weekly work hours for full-time workers, which is 45 hours for men and 40 hours for women. Individuals working part time are assigned the median number of weekly work hours for part-time workers, which is 20 hours for both men and women.

4.5.2 Wage process

The model of retirement presented in section 4.3 allows for individuals to work full-time, part-time and to be out of work at different points during their lifetime. No restriction is imposed on individuals' ability to go back to full-time work after spells of part-time work or full-retirement. This is done in order to accommodate the behavior of a small proportion of individuals who actually go back to work after retirement. However, the data show a considerable amount of persistence in the retirement decision. Most individuals who move into a part-time job never go back to full-time work; and most individuals who stop working never go back to work.

When matching these transitional patterns, I find that in the absence of any cost associated to switching from one work status to another, the model predicts that individuals move in and out of the labor force more often than they actually do in the data. Matching these transitions accurately, however, is crucial in the context of this chapter. In order to determine which couples are retiring jointly we need a clean measure of the retirement timing of each spouse, that is, the first period they are out of the labor force. This measure becomes very inaccurate if the simulated individuals keep switching in and out of the labor force.

In reality there are likely to be costs associated to switching work status. An individual who leaves her full-time job loses all the returns to tenure and firm-specific capital, and is unlikely to receive a comparable wage offer if she decides to go back to full-time work after a period of retirement or semi-retirement. I capture these costs in the model by assuming that individuals who work part-time or do not work at all during a period suffer a permanent wage depreciation. The different rates of wage depreciation associated to part-time work and retirement will be estimated directly from the structural model.

Therefore, I proceed as follows to estimate the wage process parameters: first, I follow the procedure outlined in chapter 3 to estimate the wage process of individuals working full-time. For the purposes of this chapter, the estimation is carried out pooling individuals with no pension or a DC pension.

Estimates of the selection equation for married men aged 51 to 75 are reported in the first column of table 4.5 in appendix 3.E. Results for women are presented in the second column of the same table.

The estimates of the selection processes are used to generate inverse Mills ratios for each gender. These are included as regressors in the wage equation. Estimates for the wage equation for men and women are reported in columns 1 and 2 of table 4.6 in appendix 3.E, respectively.

The residuals from the wage regressions are used to estimate the variance of the wage shocks. Estimates for men and women are reported in table 4.1 below.

Table 4.1: Standard deviation of persistent component of wages.

	Men	Women
σ^2_ζ	0.016**	0.005**
	(0.002)	(0.001)

Finally, the rates of wage depreciation associated to part-time work and retirement are estimated from the structural model, together with the preference parameters, in section 4.6.

4.5.3 Health Expenditures

The probability that a household has zero health costs in a given year, shown in the first series of figure 4.9, does not show a clear trend with age. This could be a result of mortality bias if households with no health costs are more likely to survive as they age. To check whether this is the case, in the second series of figure 4.9 I plot the probability of zero health costs as a function of the husband's age for households who survive throughout the 9 waves of the panel, and the results remain unchanged. Hence I will assume a constant probability of zero health costs in a given year equal to 2.5%.

The log of household health costs is modeled as a function of the husband's age and indicators that either the husband or wife are eligible for Medicare. I estimate the coefficients of these variables by fixed effects, rather than OLS, for two reasons. First, OLS estimates may be affected by mortality bias if households with low medical expenditures are more likely to survive than those with high medical expenditures. Fixed effects avoids this problem, providing an estimate of how health costs change for the same couples as they age. Second, in my estimation sample I combine observations from the HRS cohort with observations from the Children of the Depression (CODA) cohort, which samples individuals born between 1923 and 1930 and their spouses, and the Aging and Health Dynamics (AHEAD) cohort, which includes individuals born before 1923 and their spouses. Few individuals from the HRS cohort have reached age 80 in 2008. I use the health cost information from the older cohorts to estimate the evolution of these costs at older ages. The different cohorts are likely to differ in many observable and unobservable respects, and the old ones may have lower average medical expenditures than the HRS cohort. The fixed effects estimator controls for cohort effects.

Table 4.7 shows the results of the fixed effects estimation of equation 4.3.6. Household health costs increase convexly with husband's age. They are not significantly affected when the husband becomes eligible for Medicare at age 65, and they decrease slightly when the wife becomes eligible for Medicare, although the effect is not statistically significant. Next I compute an estimate of the error term in equation 4.3.6, including the fixed effect, and estimate its variance. The second panel of table 4.7 shows the skewness and kurtosis of the distribution of the error term. A test based on these values fails to reject normality of the residuals. The estimate for the standard deviation of the residuals is 1.1.

As mentioned above, the estimation sample includes individuals from different cohorts. The average fixed effect varies by cohort, as expected in the presence of cohort effects. Average fixed effects are lower the younger the wife is with respect to the husband, and they are higher for HRS households where both spouses have a defined contribution pension or no pension than for those where at least one spouse has a defined benefit pension. When simulating the structural model, I assign to each household the average fixed effect of household in the HRS cohort with the same age difference between spouses and who do not have a defined benefit plan.

4.5.4 Remaining Calibrations of Exogenous Parameters

Gender-specific health transition probabilities, conditional on health status on the previous period, are calibrated to those observed in the data.

I take unconditional survival probabilities from the life table used by the US Social Security Administration[17] for the cohort born between 1930 and 1939 -the HRS sample includes individuals born from 1931 to 1941 and their spouses-. Survival probabilities conditional on health status are obtained applying Bayes' rule, separately for men and women.

$$prob(survival_t|M_{t-1} = good) = \frac{prob(M_{t-1} = good|survival_t)}{prob(M_{t-1} = good)} \times prob(survival_t),$$

where all probabilities except for the unconditional survival probability are calibrated from the data.

The means-tested consumption floor provided by transfers is set to $633 per household, per month. This is the (means-tested) amount of Supplemental Social Security Income that a couple aged 65 or older and on income support would have received in 1992.

4.6 Estimation of Preference Parameters

4.6.1 Initial Conditions

To generate the initial conditions I take random draws from the empirical joint distribution of household assets, male and female wage fixed effects and lifetime earnings for couples where the husband is 55 to 60 years old and the wife is 0 to 5 years younger than the husband.

[17] "Life Tables for the United States Social Security Area 1900-2100". Social Security Administration. Office of the Chief Actuary. August 2005.

4.6.2 Parameter Estimates

I first estimate a version of the model where the parameters measuring the leisure complementarities (α_2^m and α_2^f) are restricted to being equal to 0. Results from this estimation are presented in column 1 of table 4.2. The results indicate that the share of consumption in the husband's utility function, α_1^m, is considerably larger than in the wife's utility function (α_1^f).

Regarding the wage process parameters, the results indicate that husbands' and the wives' wages depreciate by almost 10% and 11%, respectively, per year working part-time. Their wages depreciate by around 20 and 22 percentage points per year spent out of work. These depreciation costs explain why most people who start working part time don't go back into full time work, and most people who stop working don't go back into work. Notice that the depreciation associated with part-time work for elderly individuals need not be as high for younger individuals, as for the former the switch from full-time into part-time work usually implies a move from their career job into a bridge job and semi-retirement.

Table 4.2: Preference and Wage Process Parameter Estimates

Parameter and definition		Specification	
		(1)	(2)
α_1^m	Consumption share, male U function	0.5102	0.5274
			(0.0061)
α_1^f	Consumption share, female U function	0.4295	0.4334
			(0.0043)
α_2	Value of shared retirement		0.0891
			(0.0079)
δ_{PT}^m	Male's wage depreciation per year working PT	0.9051	0.9258
			(0.0383)
δ_{PT}^f	Female's wage depreciation per year working PT	0.8933	0.9219
			(0.0334)
δ_R^m	Male's wage depreciation per year of retirement	0.8092	0.8609
			(0.0436)
δ_R^f	Female's wage depreciation per year of retirement	0.7795	0.7841
			(0.0336)
Value GMM criterion		0.2058	0.1404

Next, I estimate a version of the model where no restriction is imposed on the leisure complementarity parameter. Results for this estimation are presented in column 2 of table 4.2. The first noticeable point regards the differences in estimates for the parameters that are common to the previous specification. In particular, the consumption shares in both spouses's utility functions are larger, and the wage depreciation rates smaller, in the presence of leisure complementarities. This suggest that, in the restricted model, the timing of those retirement that are induced by leisure complementarities was attributed to spouses' higher taste for leisure relative to consumption and a higher cost of re-entry into the labor force after retirement.

The parameter measuring leisure complementarity is positive and significant. The estimated value of 0.891 implies that each spouse gets an extra amount of leisure equal to 9% of the leisure endowment, or 360 extra hours per year, by sharing retirement with their partner.

Figure 4.1 shows the simulated versus the true profiles for the moments I match in the estimation process. Overall, the simulated profiles appear consistent with the data. The two graphs on the top row show that the model predicts very closely total male and female participation. The graphs on the second row of Figure 4.1 compare the simulated rates of full-time and part-time participation for men and women with the actual ones. The model predicts these rates quite closely for men, although it substantially underpredicts part-time participation for women. This could be due to two things: the number of hours worked when employed part- and full-time has been set equal to the median hours worked by part- and full-time workers, respectively, for men and women. There may exist a fixed cost of work for women that does not exist (or is lower) for men. Adding this cost as a fixed number of extra hours lost when working for women would likely decrease the rate of full-time and increase the rate of part-time participation for women, increasing the overall fit. Another possibility is that the part-time wage premium, which has been set equal to 25% for both men and women is actually lower for women. A lower part-time wage premium would also lead women to choose to work part-time more frequently.

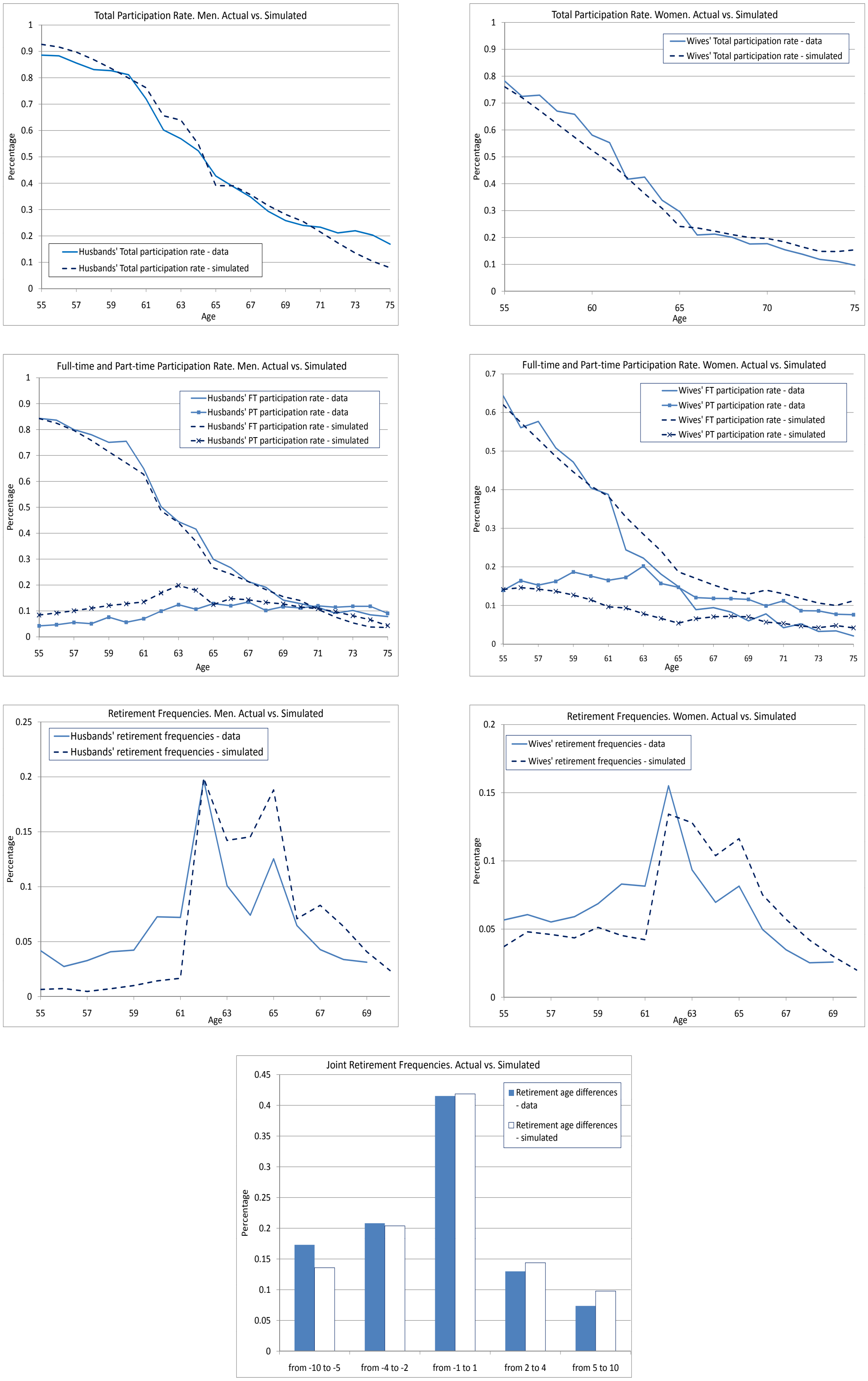
The graph on the left of the third row of figure 4.1 shows the retirement age distribution for men between ages 55 and 69. The graph on the right is the equivalent for women. The model captures the spikes at ages 62 and 65 for both men and women, but it substantially overpredicts retirements for both sexes at age 65. One possible reason for this is that the estimated version of the model does not account for the role of health. If bad health increases the cost of work, it can lead to earlier retirements for some individuals.

Finally, the graph on the last row of figure 4.1 shows the distribution of differences in retirement dates between husbands and wives. The bar at the center of the histogram measures the proportion of couples where the husband retires within a year of his wife, i.e. the *joint* retirements. The model does a good job of predicting the proportion of joint retirements. However, it underpredicts the proportion of couples where the husband retires at an earlier date than the wife, while it overpredicts that of couples where the wife is the first to retire.

4.6.3 The Role of Complementarities

To offer a sense of the importance of complementarities in determining joint retirements, I experiment with the following changes to the model. First, I restrict the complementarity parameter to being equal to 0. Results from this experiment are shown on the third series in figure 4.2. Taking away the extra value that spouses get from sharing their retirement decreases predicted joint retirements by 3.77 percentage points. Next, I change the social security function and eliminate the spousal benefit, which gives the spouse with the lower lifetime earnings (usually the wife) the right to supplement her pension until her benefits are equal to up to a half those of her husband. In this case, the predicted percentage

Figure 4.1: Simulated Profiles vs. True Profiles.

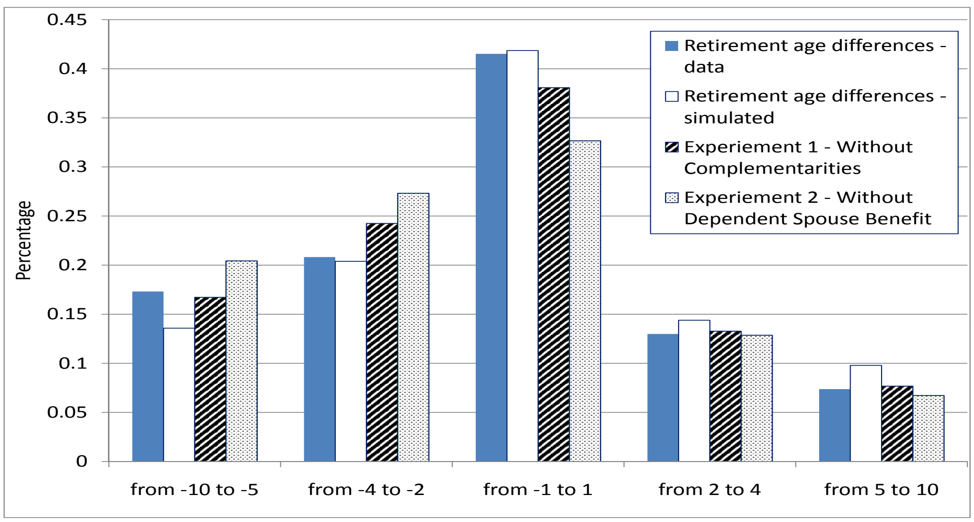


of joint retirements decreases by a further 5.42 percentage points.

These experiments suggest that, while leisure complementarities play an important role in leading spouses to retire together, the effect of the social security spousal benefit leads to an even larger share of joint retirement.

Another point worth mentioning in relation to figure 4.2 is that both eliminating the leisure complementarities and the spousal benefit leads to an increase in the proportion of couples where the husband retires earlier than the wife. This suggests that both incentives for joint retirement act by either anticipating the retirement of the wives or delaying the retirement of the husbands.

Figure 4.2: Joint Retirement Frequencies. Data, Simulation, and Experiments.



4.7 Conclusions

In this chapter, I present a stochastic dynamic model of older couples' participation and savings decisions.

The model accounts in a detailed way for the main financial incentives and sources of uncertainty for couples approaching retirement. Couples are heterogeneous in household wealth, wages and lifetime earnings. They face uncertainty in wage income, survival, and out-of-pocket medical expenditures.

The model allows for interactions in spouses' leisure. In particular, spouses may enjoy retirement more (complementarity) or less (substitutability) when their partner is retired too.

Estimation results show evidence of leisure complementarities. When both partners are retired, each one enjoys an extra amount of leisure equal to 9% of the leisure endowment, or 360 hours per year.

The model shows the importance of accurately accounting for incentives to joint retirement acting through the budget constraint in order to accurately estimate the role of complementarities. The social security dependent spouse benefit alone is responsible for almost twice as many joint retirements as the existence of leisure complementarities. These retirements would likely be attributed to complementarities in a framework where the role of social security was not appropriately modeled.

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4.8 Appendix 3.A. Mathematical Appendix

Computation of the integral with respect to out-of-pocket medical expenditures.

In order to solve period t's problem, we need an approximation to the expected value of V_{t+1}. This expected value is taken with respect to health status in $t+1$, survival into $t+1$, health costs in period t[18] and, when the husband is younger than 75 and/or the wife younger than 70, wages in period $t+1$. In this section I describe the steps involved in the computation of the expected value with respect to health costs.

$$E_{hc^m,hc^f}\widehat{V}_{t+1}(z_{t+1},x_{t+1} \mid z_t,x_t) \tag{4.8.1}$$

Recall that the probability that health costs are positive, and the logarithm of health costs have been modeled as follows:

$$p(hc_{it}>0)=p^1_{it}=X_{it}\beta_1+\psi^1_{it}$$

$$\begin{aligned}\ln hc_{it} &= X_{it}\beta_2+\psi^2_{it},\\ \psi^2_{it} &\sim N(0,\sigma^2_{\psi^2})\end{aligned}$$

Hence the positive health costs are lognormally distributed:

$$hc_{it} \mid X_{it} \sim \log N(X_{it}\widehat{\beta}^2,\widehat{\sigma}^2_{\psi^2})$$

Omitting the conditioning on the state variables that are not relevant to the solution of this integral, (A1) can be re-written as follows:

$$\begin{aligned}&E_{hc^m,hc^f}\widehat{V}_{t+1}(z_{t+1},x_{t+1} \mid z_t,x_t)=\\ &+(1-p^{1,m}_{it})\times(1-p^{1,f}_{it})\times\widehat{V}_{t+1}(hc^m_{it}=0,hc^f_{it}=0)+\\ &+(1-p^{1,m}_{it})\times p^{1,f}_{it}\times\int_0^\infty\widehat{V}_{t+1}(hc^m_{it}=0,hc^f_{it})f(hc^f_{it}\mid X_{it})dhc^f+\\ &+p^{1,m}_{it}\times(1-p^{1,f}_{it})\times\int_0^\infty\widehat{V}_{t+1}(hc^m_{it},hc^f_{it}=0)f(hc^m_{it}\mid X_{it})dhc^m+\\ &+p^{1,m}_{it}\times p^{1,f}_{it}\times\int_0^\infty\int_0^\infty\widehat{V}_{t+1}(hc^m_{it},hc^f_{it})f(hc^m_{it}\mid X_{it})f(hc^f_{it}\mid X_{it})dhc^m dhc^f.\end{aligned}$$

[18] It is assumed that the realisation of the medical cost draw happens at the end of the period, after households have made their consumption and work decisions.

Below I describe in detail the computation of the integral with respect to the husband's health costs. The value of the integral with respect to the wife's health costs is computed in a symmetric way, while the double integral is solved using a two-dimensional Gauss-Hermite integration rule.

Define K as:

$$K \equiv \int_0^{+\infty} \widehat{V}_{t+1}(hc_{it}^m) f(hc_{it}^m \mid X_{it}) dhc^m$$

Since hc_{it}^m is lognormally distributed,

$$K = \int_0^{+\infty} \widehat{V}_{t+1}(hc_t^m) \frac{1}{hc_{it}^m \widehat{\sigma}_{\psi^2}^m (2\pi)^{1/2}} \exp\left\{ - \left(\frac{\ln hc_t^m - X_{it}\widehat{\beta}_2^m}{2^{1/2}\widehat{\sigma}_{\psi^2}^m} \right)^2 \right\} dhc^m$$

Using the following change of variable,

$$z_{it} = \frac{\ln hc_{it}^m - X_{it}\widehat{\beta}_2^m}{2^{1/2}\widehat{\sigma}_{\psi^2}^m},$$

yields

$$K \equiv \int_{-\infty}^{+\infty} \widehat{V}_{t+1} \left(\exp\{2^{\frac{1}{2}} \widehat{\sigma}_{\psi^2}^m z_{it} + X_{it}\widehat{\beta}_m^2\} \right) \frac{1}{\pi^{1/2}} \exp\left\{-z_{it}^2\right\} dz_1$$

The value of K is approximated using Gauss-Hermite quadrature.

$$K \approx \frac{1}{\pi^{1/2}} \sum_{j=1}^{P} \widehat{V}_{t+1} \left(\exp\{2^{1/2} \widehat{\sigma}_{\psi^2}^m \xi_j + X_{it}\widehat{\beta}_m^2\} \right) \omega_j,$$

where $\{\xi_j, \omega_j\}_{j=1}^P$ are the abscissae and weights of a one-dimensional Gauss-Hermite integration rule with P points, which can be found in standard references (e.g. Abramowitz and Stegun, 1964).

4.9 Appendix 3.B. Social Security function

Individual benefits

Benefits depend on indexed lifetime earnings. For each year of work, there is a maximum amount of earnings, from which payroll tax is deducted, which will contribute to the pension. E_t is the measure of lifetime earnings used in the model:

$$E_t \equiv \begin{cases} \sum_{j=0}^{t} \omega_j e_j^* & \text{if} \quad t \leq R \\ \sum_{j=0}^{R} \omega_j e_j^* & \text{if} \quad t > R \end{cases},$$

where $t = 0$ is the first year of earnings, R is the first year of receipt of Social Security benefits (subject to the restriction $R \geq 62$), ω is the weight used by the Social Security administration to index yearly earning, and e_t^* is defined as the minimum between yearly earnings $e_t = w_t \times h_t$ and maximum taxable earnings for that year, $e_t^{\max}$:

$$e_t^* = \min\{e_t,\ e_t^{\max}\}.$$

In order to avoid the need to keep track of every individual's whole earnings history, Average Indexed Monthly Earnings ($AIME_t$) are approximated as a function of E_t as follows:

$$AIME_t = \frac{E_t}{12 \times \max\{(t-25), 35\}}$$

Full retirement entitlement, also known as Primary Insurance Amount (PIA_t) is obtained from $AIME$ according to the Social Security formula, re-scaled by the weight κ :

$$\begin{aligned} PIA_t \quad = \quad & \kappa_t \left[0.90 \times \min\{AIME_t,\ b_0\} + 0.32 \times \min\{\max\{AIME_t - b_0, 0\},\ b_1 - b_0\} + \right. \\ & \left. +0.15 \times \max\{AIME_t - b_1,\ 0\}\right], \end{aligned}$$

where κ_t is calibrated to give an individual retiring at each possible age with the maximum possible accumulated earnings exactly the same pension she would have been awarded under the 1992 Social Security rules[19]. The bendpoints for the year 1992 are $b_0 = \$387$ and $b_1 = \$2,333$.

Benefit entitlement is determined as a function of the PIA in the period in which an individual claims benefits, PIA_R:

$$ssb_t = f(PIA_R, age_t, w_t h_t),$$

where f accounts for the actuarial adjustments for individuals who claim benefits before or after age 65, and the earnings test.

Benefits lost through the earnings test translate into increases in future benefits. This is captured in the model through increases in the value of PIA_R.

Spouses and Widowed individuals

In periods when both spouses are claiming benefits, the spouse with lowest PIA receives benefits ssb_t equal to the highest amount between her individual entitlement and entitlement based on 50% of

[19]The Social Security benefit approximation just described yields a very accurate fit for individuals with the highest possible pensions. Consequently, the highest weight used in the model is equal to 1.0517, and the lowest to 0.9915.

her partners' PIA.

Individuals who become widowed can claim benefits based on their individual entitlement or that of their deceased partner.

4.10 Appendix 3.C. Taxes

This section describes the tax function applied to couples' income in the model. Households pay federal and payroll taxes on income. Due to the great cross-sectional variation in state taxes, those are not accounted for here. I used the rates applying to married couples filing jointly. Also, I use the standard deduction, and hence do not allow households to defer medical expenses as an itemized deduction. The tax rates and exempt amounts used below are those corresponding to the year 1992.

Payroll Tax

The payroll tax is a proportional tax imposed on employees, which is used to finance the Social Security's OASDI programme and Medicare's hospital insurance programme. The social security tax rate for employees is 6.2% of earnings up to an upper limit of $55,500. The Medicare tax rate for employees is 1.45% of earnings, and it is uncapped.

Defining individual annual earned income as

$$e_t^i \equiv w_t^i \times h_t^i, \quad \text{for } i = m, f,$$

each spouses' payroll tax contribution is given by:

$$\tau^P e_t^i = (0.062) \times \min\{\$55,500, e_t^i\} + 0.0145 \times e_t^i, \text{ for } i = m, f$$

Federal Income Tax

The income tax is a progressive tax on labor and nonlabor income. The standard deduction for a married couple filing jointly was $6,000 in 1992. Additionally, each spouse was entitled to a further deduction of $700 if aged 65 or over.

Defining household income subject to federal income tax as

$$I_t \equiv (1 - \tau^P)e_t^m + (1 - \tau^P)e_t^f + rA_t,$$

generates the following level of post-income tax for a couple where both spouses are below age 65:

Denoting the federal income tax structure by the vector τ^I, households' post-tax income is given by:

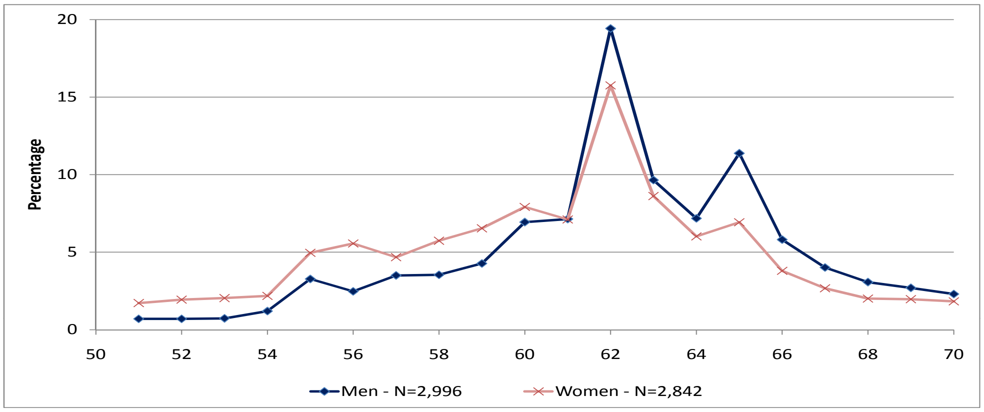
$$Y(rA_t, e_t^m, e_t^f, \tau^P, \tau^I) = (1 - \tau^I)I_t$$

Table 4.3: Federal Income Tax Structure

Taxable income (I) (in dollars)	Post-tax Income (in dollars)	Marginal rate
$0 - 6,000$	Y	0.00
$6,000 - 41,800$	6,000 + 0.85(Y-6,000)	0.15
$41,800 - 92,500$	36,430 + 0.72(Y-41,800)	0.28
$92,500$ and over	72,934 + 0.69(Y-92,500)	0.31

4.11 Appendix 3.D. Figures

Figure 4.3: Retirement frequencies for married men and women at ages 51 to 70.



Retirement frequency at age j defined as the proportion of all retirements observed between ages 51 and 70 that takes place at age j.

Figure 4.4: Differences in spouses' retirement dates as a function of age difference between them.

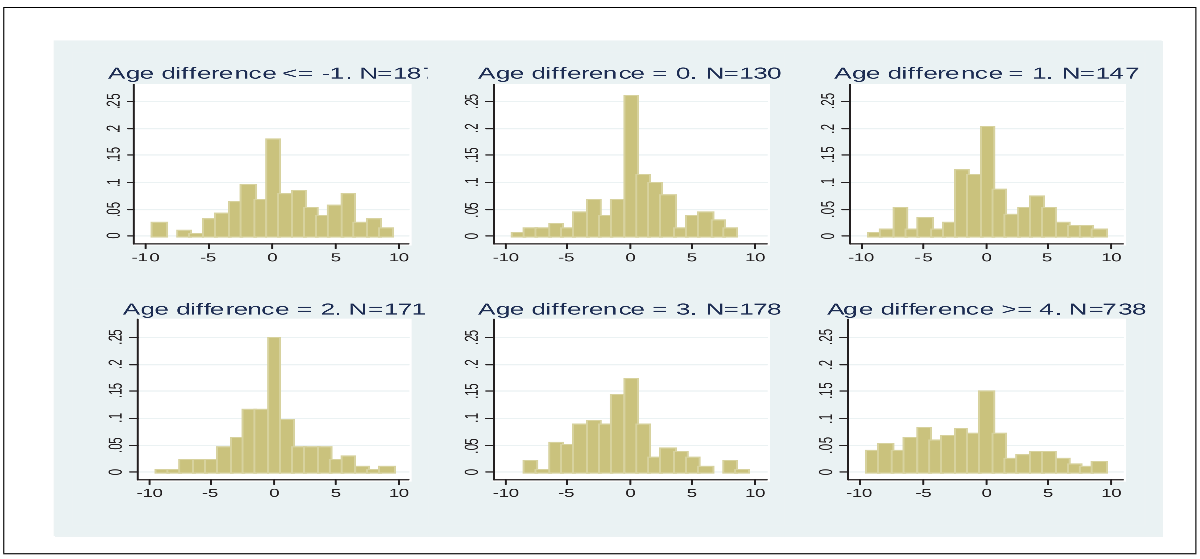


Figure 4.5: Comparison of actual and assumed Social Security claiming date. Men.

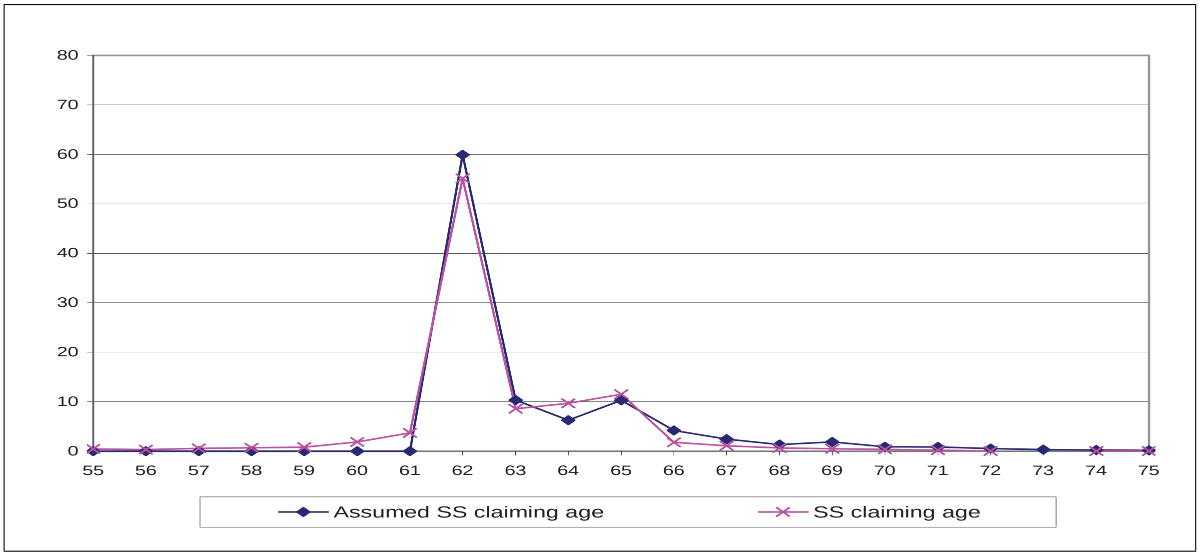


Figure 4.6: Comparison of actual and assumed Social Security claiming date. Women.

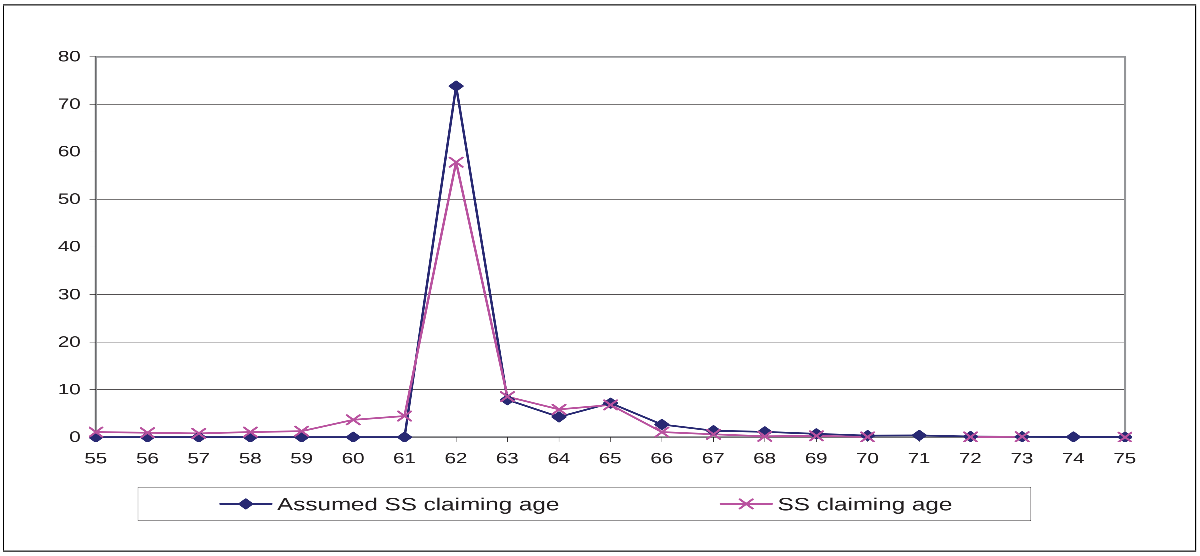


Figure 4.7: Retirement frequencies by pension type. Men.

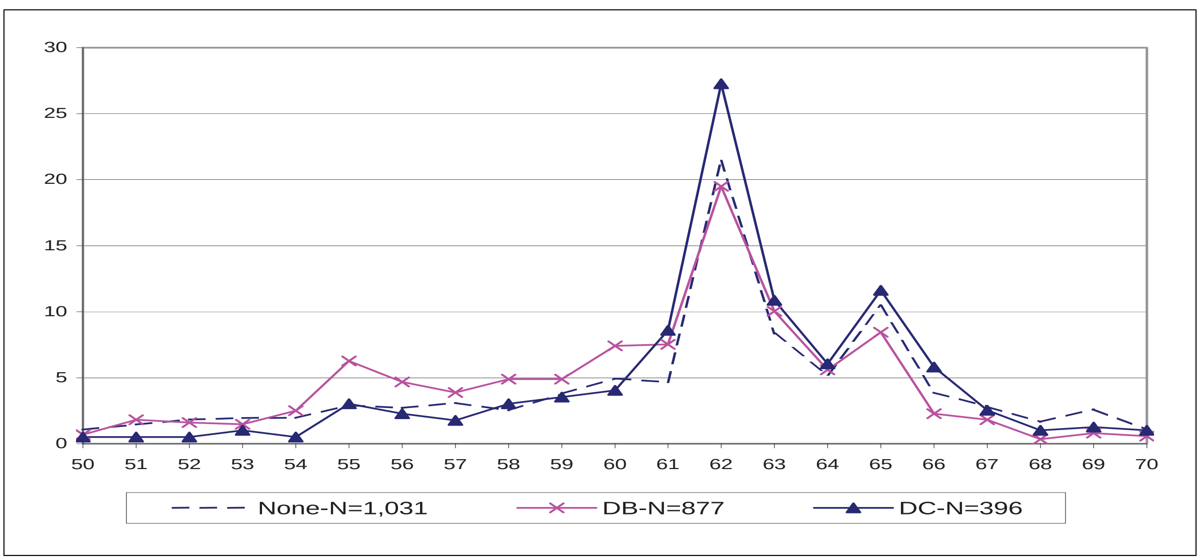


Figure 4.8: Retirement frequencies by pension type. Women.

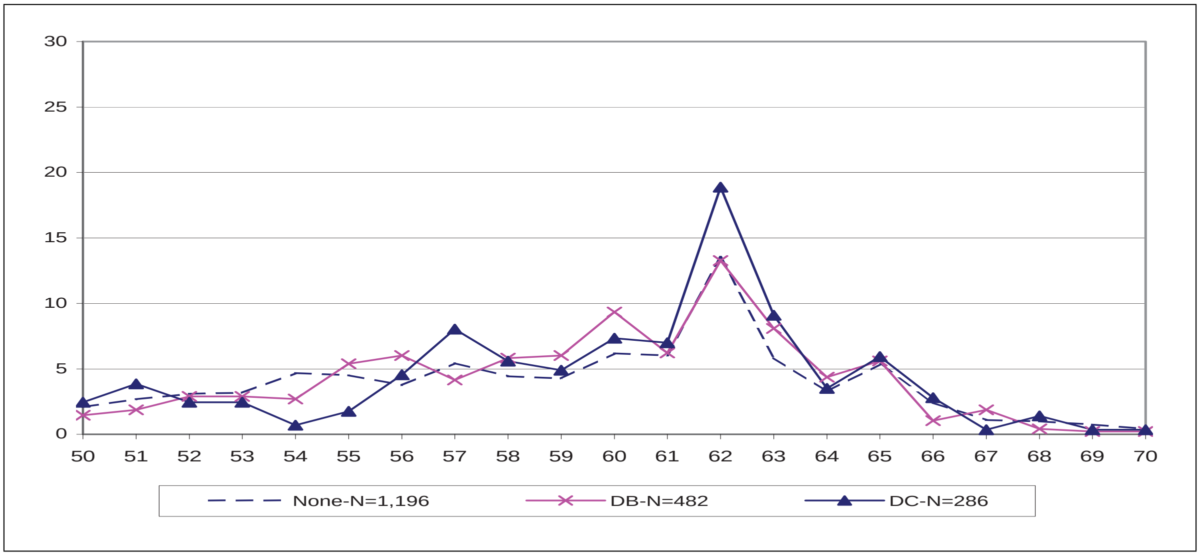
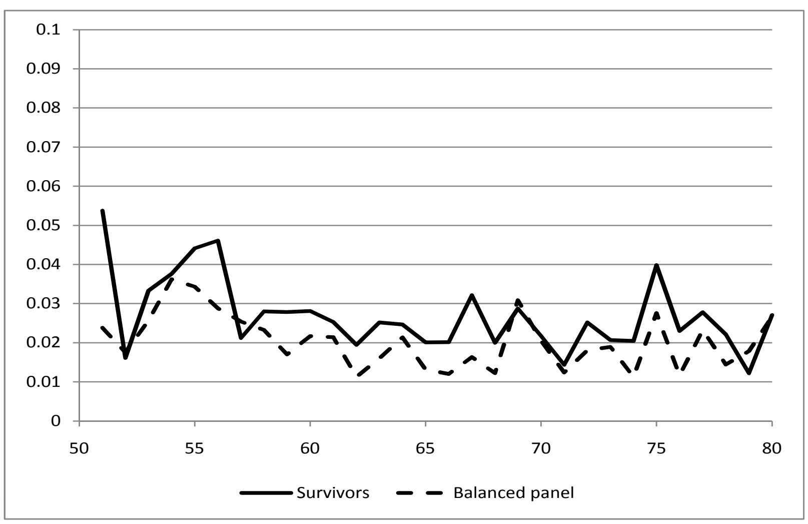


Figure 4.9: Probability of zero household health costs as a function of husband's age.



NOTE. - Sample: For the first series, the probability at every age is computed using all households from the HRS cohort where both spouses are alive at that age. The second series controls for mortality bias by using only observations for those households where both spouses are still alive at the end of the 9th wave.

4.12 Appendix 3.E. Tables

Table 4.4: Descriptive Statistics by Pension Type.

	None	DB only	DC only	None	DB only	DC only
Percentage population [1]	31.8	39.0	26.6	55.2	25.6	18.0
Employment						
% working	88.8	98.8	97.3	43.6	98.1	94.7
Median hourly wage in $ [2]	9.3	15.8	13.7	6.3	10.9	8.9
Health insurance						
% with retiree health coverage	13.4	69.7	42.3	3.6	46.1	27.8
% with tied health coverage	7.2	11.2	19.8	2.8	14.3	14.1
% with no empl. health insurance	72.9	10.5	24.9	91.5	27.4	44.7
Health Status						
% in bad health	19.0	10.5	9.3	21.2	9.6	8.8
Household wealth in $ [3]						
Median	107,000	119,000	132,500	111,000	134,960	125,000
25^{th} percentile	30,300	61,000	57,000	43,300	66,300	54,750
75^{th} percentile	308,344	226,000	278,000	273,000	267,000	225,500.0
Demographics						
Average age	56.8	55.7	55.6	55.4	54.7	54.4
% College education	30.4	43.9	48.9	25.4	45.1	37.3
% High-School graduates	33.3	37.9	32.2	41.7	41.9	47.0
N	1,105	1,355	923	2,169	1,153	875

NOTE. - Sample includes all married men (women) from the HRS cohort interviewed in 1992 who had not retired or were disabled. [1] Percentages do not sum to 100 because individuals who have both a DB and a DC pension are excluded. [2] Only for individuals who are employed. [3] Wealth measure includes housing and real estate, vehicles, checking and savings accounts, CD's, Treasure bills and government bonds, IRA's, Keoghs, stocks, the value of business, mutual funds, bonds, and other assets, minus mortgages and other debts. It does not include pension wealth for defined benefit plan holders or 401(k) balances.

Table 4.5: Estimates of selection equation for married men and women.

	Men	Women
$\text{age}_{rt}/10$	-0.453	0.052
	(0.543)	(0.677)
$\text{age}^2_{rt}/100$	-0.035	-0.080
	(0.045)	(0.059)
d62_{rt}	-0.309**	-0.231**
	(0.043)	(0.053)
d65_{rt}	-0.258**	-0.135
	(0.053)	(0.074)
bad_h_{rt}	-0.206**	-0.157**
	(0.047)	(0.056)
wealth_{rt} \$(0000)	-0.004**	-0.003**
	(0.001)	(0.001)
d62_{st}	-0.127**	-0.014
	(0.038)	(0.034)
DB_{st}	0.003	-0.103*
	(0.040)	(0.042)
edu1_r	-0.219**	0.189**
	(0.038)	(0.042)
$\text{edu1}_r \times \text{DC}_r$	0.574**	0.661**
	(0.048)	(0.052)
edu2_r	-0.120**	-0.082*
	(0.036)	(0.039)
$\text{edu2}_r \times \text{DC}_r$	0.498**	0.878**
	(0.049)	(0.047)
$\overline{\text{age}}_r$	0.972	1.875**
	(0.513)	(0.457)
$\overline{\text{age}}^2_r$	-0.080*	-0.135**
	(0.041)	(0.039)
$\overline{\text{bad\_h}}_r$	-0.434**	-0.325**
	(0.062)	(0.072)
$\overline{\text{wealth}}_r$ (\$0000)	0.000	-0.003**
	(0.001)	(0.001)
mother_educ_r	0.027*	-0.045**
	(0.012)	(0.014)
constant	1.369	-4.422*
	(1.844)	(1.907)
N	17,139	18,312

NOTE. - Robust standard errors in parentheses. * indicates the coefficient is significant at 5%. ** indicates significance at 1%. Both regressions include year and cohort dummies and a measure of the unemployment rate at period t for men/women aged 55 and older in order to control for economy-wide effects. Dummies of the form $\text{d}age_j$ are equal to 1 if the individual is older than age_j. Dummies of the form $\text{d}age_j^{sp}$ are equal to 1 if the spouse is older than age_j. The dummy bad_h is equal to 1 if the individual is in fair or poor health. The dummies redu1 and redu2 indicate whether the individual has at least some college or is a high school graduate, respectively.

Table 4.6: Estimates of wage equation for married men and women.

	Dependent variable: $\ln w_{rt}$	
	Men	Women
age_{it}	2.234**	1.435*
	(0.560)	(0.642)
$age_{it}^2/100$	-0.216**	-0.136*
	(0.053)	(0.064)
bad_h_{it}	-0.061*	-0.049
	(0.028)	(0.032)
$edu1_i$	0.222**	0.438**
	(0.037)	(0.050)
$edu1_{it}\times$ DC	0.303**	0.212*
	(0.059)	(0.097)
$edu2_i$	0.075*	0.093*
	(0.034)	(0.044)
$edu2_{it}\times$ DC	0.200**	0.348**
	(0.056)	(0.116)
$\overline{age}_{it}$	0.009	-0.213
	(0.377)	(0.415)
$\overline{age}_{it}^2/100$	-0.010	0.009
	(0.030)	(0.034)
$\overline{bad\_h}_{it}$	-0.313**	-0.231**
	(0.050)	(0.063)
$\overline{wealth}_{it}$	0.003**	0.002**
	(0.000)	(0.001)
mother_educ$_r$	0.060**	0.001
	(0.011)	(0.014)
$\widehat{\lambda}_{it}^0$	0.401**	0.347*
	(0.105)	(0.172)
$\widehat{\lambda}_{it}^{DC}$	0.107**	0.108**
	(0.040)	(0.037)
constant	-3.490	-1.410
	(1.796)	(2.208)
N	6,218	3,663
R^2	0.273	0.378

NOTE. - Standard errors (in parenthesis) obtained from 2,500 bootstrap replications, accounting for estimation of inverse Mills ratios in first stage. * indicates the coefficient is significant at 5%. ** indicates significance at 1%. The regressions include year and cohort dummies and a measure of the unemployment rate at period t for men/women aged 55 and older in order to control for economy-wide effects. Dummies of the form dage_j are equal to 1 if the individual is older than age_j. The dummy bad_h is equal to 1 if the individual is in fair or poor health. The dummies redu1 and redu2 indicate whether the individual has at least some college or is a high school graduate, respectively.

Table 4.7: Estimates of household health cost process.

	Dependent variable: $\ln hc_t$
husband's age / 10	-0.809**
	(0.302)
husband's age sq / 100	0.092**
	(0.013)
husband eligible for Medicare	0.051
	(0.032)
Wife eligible for Medicare	-0.014
	(0.030)
constant	8.48**
	(1.57)
N	20,973
Skewness	-0.008
Kurtosis	3.016
Normality test (p-value)	0.7851
$\hat{\sigma}_\psi$	1.100**
	(0.050)

NOTE. - Robust standard errors in parentheses. * indicates significance at 5%; ** indicates significance at 1%. Sample includes households from HRS, CODA, and AHEAD cohorts where both husband and wife were born before 1942. Time dummies were included in the regression. Standard error of estimate of standard deviation of residuals obtained from 1,000 bootstrap replications of fixed effects regression.