Journal of Econometrics 145 (2008) 21–42

Contents lists available at ScienceDirect

Journal of Econometrics

journal homepage: www.elsevier.com/locate/jeconom

Social security and the retirement and savings behavior of low-income households

Wilbert van der Klaauw [a,*], Kenneth I. Wolpin [b]

[a] Federal Reserve Bank of New York, United States
[b] University of Pennsylvania, United States

ARTICLE INFO

Article history:
Available online 23 May 2008

JEL classification:
J01
J14
J18

Keywords:
Retirement
Social security
Structural estimation

ABSTRACT

In this paper, we develop and estimate a model of retirement and savings incorporating limited borrowing, stochastic wage offers, health status and survival, social security benefits, Medicare and employer-provided health insurance coverage, and intentional bequests. The model is estimated on a sample of relatively poor households from the first three waves of the Health and Retirement Study (HRS), for whom we would expect social security income to be of particular importance. The estimated model is used to simulate the responses to changes in social security rules, including changes in benefit levels, in the payroll tax, in the social security earnings tax and in early and normal retirement ages. Welfare and budget consequences are estimated.

Executive summary

With the oldest cohort of the baby-boom generation just beginning to reach retirement age, the impending wave of retirements during the next two decades is expected to place mounting budgetary pressures on the federal government. Consequently, the reform of Social Security and Medicare has become a central policy issue, with policy makers facing the difficult task of choosing from among a large set of alternative policy proposals. To help this debate, we develop and estimate a rich dynamic model of retirement and savings decisions for a low-income subsample of households from the Health and Retirement Study. This subset of households is expected to rely heavily on government benefits in retirement, and includes both unmarried individuals and married couples.

Our model of labor supply and consumption choices includes a detailed specification of social security rules, borrowing constraints, stochastic wage offers, uncertain health and survival, Medicare and employer-provided health insurance coverage, as well as a bequest motive. We use the estimates of our model to simulate the impact of several counterfactual experiments corresponding to changes in social security rules on household labor supply, income and consumption. These include reductions in benefit levels, the removal of the earnings test, elimination of early retirement, and postponement of the earliest retirement age to 70.

In all cases, the model predicts sharp increases in average annual hours of work and in full-time employment at ages 62–69, and smaller variable responses in hours before age 62. There is considerable heterogeneity in responses, with those of singles generally exceeding those of married individuals, and those of husbands being considerably larger than those of wives. The employment responses are accompanied by modest, but not inconsequential, changes in net assets holdings, indicating that both labor supply and savings decisions play important roles in mitigating these reforms' impacts on consumption and welfare. Our experiments illustrate the existence of potentially important trade-offs faced by policy makers in balancing consumer welfare losses against revenue increases.

1. Introduction

The literature on retirement behavior has grown rapidly during the last twenty years. Much of that growth has been due to recent methodological advances in the structural estimation of dynamic discrete choice models of behavior under uncertainty. Unlike earlier static lifetime models (e.g., Fields and Mitchell (1984)), dynamic models account for the sequential nature of the retirement process in which individuals adjust their behavior as events unfold. Structural estimation of the fundamental parameters of preferences and constraints as opposed to "reduced form" analyses permits the simulation of policy experiments that act directly on constraints and which may be outside of current or prior policy regimes.

* Corresponding address: Microeconomic and Regional Studies Function, Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 10045, United States. Tel.: +1 212 720 5916; fax: +1 212 720 1844.
E-mail address: Wilbert.VanderKlaauw@ny.frb.org (W. van der Klaauw).

0304-4076/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.jeconom.2008.05.004

Much of the focus in the initial attempts to formulate and estimate a forward-looking model of retirement behavior has been on explaining the empirical regularities of a declining full-time employment rate with age (for males), with particularly large drops at ages 62 and 65, as well as the substantial heterogeneity in retirement behavior across individuals (see Gustman and Steinmeier (1986), Stock and Wise (1990), Berkovec and Stern (1991), Phelan and Rust (1991), Lumsdaine et al. (1992, 1994, 1996), Rust and Phelan (1997) and Blau and Gilleskie (2006, 2008)). Besides establishing the importance of health, wealth and labor market opportunities in explaining retirement patterns, these studies also point to the significance of capital and health insurance market imperfections and social security and private pension rules.

Social security rules may affect work decisions through the structure of the benefits schedule, the earnings tax and its actuarially unfair delayed retirement credit associated with postponing retirement beyond the normal retirement age. Private pensions often include substantial incentives to remain with a firm until a given age, combined with substantial incentives to leave the firm at an older age. Therefore, even in an economy with perfect capital markets where individuals can smooth consumption by borrowing against future pension and social security income, public and private pensions can produce delays in retirement and spikes in retirement rates at certain ages. However, their importance for labor supply decisions is likely to be substantially greater in the presence of borrowing constraints, which may prevent many low-wage individuals, who optimally accumulate relatively little tangible wealth, from retiring before reaching the age at which they first become eligible to receive benefits. A similar role can be attributed to the Medicare program when health insurance markets are imperfect. Limited private health insurance options could make it too risky for individuals who do not have access to employer-provided retiree health insurance to retire prior to being eligible for Medicare at 65.

Rust and Phelan (1997) provide empirical evidence of the importance of market imperfections, attributing a large part of the drop in employment at age 62 to social security eligibility and at age 65 to Medicare eligibility. Blau and Gilleskie (2006, 2008) also find significant, although more modest, employment effects of employer-provided health insurance. However, there is an important reason to believe that the roles attributed to social security and employer-provided health insurance in these studies may be overestimated. The models on which these results are based do not allow households to save, thereby removing an important instrument through which to smooth consumption (and facilitate early retirement) and to self-insure against future health expenditures. Gustman and Steinmeier (1986, 1994) instead make the alternative extreme assumption of perfect capital markets, in which individuals can freely borrow against future earnings and pension income, an assumption that is likely to lead to an underestimation of the importance of social security and employer linked health insurance.

Other empirical studies have found the effect of assets other than social security and pension annuities on the timing of retirement to be weak (Blau, 1994; Diamond and Hausman, 1984; Sickles and Taubman, 1986). However, these studies do not capture completely the complex interactions that exist between savings, health status, social security benefits, health insurance coverage and work decisions. Moreover, many of these studies take accumulated savings or assets to be exogenous in their analysis. Several studies, such as those by Feldstein (1974) and Bernheim and Levin (1989) have found social security to depress savings, which suggests that the exogeneity assumption may be incorrect.

An accurate assessment of the magnitude and manner in which social security benefits influence behavior is crucial for credibly forecasting the impact of changing the social security program, a major goal of this paper. We, therefore, develop and estimate a model of retirement and savings incorporating limited borrowing, stochastic wage offers, health status and survival, social security benefits, Medicare and employer-provided health insurance coverage, and intentional bequests. The model is estimated on a sample of relatively poor households from the first three waves of the Health and Retirement Study (HRS), for whom we would expect social security income to be of particular importance. The estimated model is used to simulate the responses to several counterfactual experiments corresponding to changes in social security rules. These include changes in benefit levels, in the payroll tax, in the social security earnings tax and in early and normal retirement ages.[1]

Our model shares features with many recent papers that have estimated models of retirement behavior, but is more comprehensive and introduces a number of new elements. It incorporates savings behavior with limited borrowing as in Gustman and Steinmeier (2005), French (2005) and French and Jones (2007), and also models the joint labor supply decision of married couples as in Gustman and Steinmeier (2000) and Blau and Gilleskie (2008). The flexibility to augment household income through spousal work is potentially an important instrument to insure against wage and health shocks, as well as a tool for smoothing consumption. We explicitly incorporate the social security benefit rules which apply to couples, allow for health insurance coverage through the spouse and incorporate the possibility of direct preferences for shared leisure and of assortative mating on preferences and on health and market skill endowments.

Wages in our model are stochastic as in French (2005), but also depend on accumulated work experience and tenure and we allow individuals to change jobs which may or may not offer health insurance. Like Berkovec and Stern (1991), in characterizing employment choices we distinguish between part-time and full-time work, model job-to-job transitions and instead of treating retirement as an absorbing state, allow returns from non-employment into the labor force. However, we do not explicitly consider the purchase of private health insurance and medical expenditure decisions (Blau and Gilleskie, 2006), private pensions on current jobs (Lumsdaine et al., 1992, 1994, 1996; French, 2005; Blau and Gilleskie, 2006) nor do we model disability insurance applications and benefit receipt (Rust et al., 2003).

Our model accommodates observed and unobserved heterogeneity in preferences, wages, health transitions and mortality risks. In addition, individuals in our model have expectations over changes in social security policy. Myopic beliefs about the social security system may be unrealistic given the long history of changes in the social security rules and benefit levels which have been enacted over the 1969–90 period, with major changes in 1972, 1977 and 1983. As Moffitt (1987) has argued, the magnitude of behavioral responses to policy changes will depend strongly on the extent to which these policy changes were anticipated. In an analysis of data from the Survey of Economic Expectations on subjective expectations of future social benefit receipt, Dominitz et al. (2003) in fact conclude that a sizeable proportion of their sample, and especially among the young, consider it fairly likely that the social security program will no longer exist at the time they retire.

A final contribution of this paper is that we make explicit use of subjective expectations in the estimation of our model. The Health and Retirement Study contains a set of probabilistic questions on, among others, retirement and longevity expectations. For example,

[1] Recent studies of the effects of similar changes in social security rules have been inconclusive. For example, French (2005) predicts no effect of raising the early retirement age on simulated work choices at age 62, but Gustman and Steinmeier (2005) forecast a large increase in full-time employment at that age.

all those employed in 1992 were asked for their subjective probability that they would be working full-time after reaching ages 62 and 65, and all respondents were asked about their probabilities of surviving to age 75 and 85. Reported expectations about future choices have precise interpretations within the context of dynamic behavioral models. Just as current choices are taken to portray optimal behavior given current information, expectations about future choices portray optimal future behavior conditional on current information. As a result, subjective data provide useful information about the decision process in the same way as do objective data (Van der Klaauw, 2000; Wolpin, 1999).

We highlight a few of the results of the counterfactual policy changes.[2] For example, for married couples, we find that a 50% reduction in social security benefits would lead to a small decline in the labor supply of both spouses at ages between 51 and 61, and a substantial increase at ages between 62 and 69, an increase that is particularly large for husbands whose full-time employment rate in this latter age range is predicted by the model to increase from 37.8% to 52.3%. Although average annual earnings thus increase in the latter age range and average net assets optimally falls, average annual household consumption falls over the 62–69 age range by 8.0% because of the reduction in benefits. Eliminating the earnings tax is predicted to have a substantial impact on labor supply, with average annual hours worked of married and single individuals between ages 62 and 69 predicted to increase by respectively 17% and 35%. Concomitantly, average net assets over that age range would increase by 8% and 21% for singles and married individuals. Finally, eliminating the option of early retirement is predicted to produce a comparable increase in average labor supply at ages 62–69, but leads to a small fall (increase) in net assets for marrieds (singles).

An evaluation of these policies' impact on welfare and government revenue indicates that while a 50% benefit reduction and an increase in the normal retirement age to 70 both lead to comparable losses in welfare, the net revenue gain associated with the former is only 40% as large as that from the latter. An increase in the payroll tax rate to 15% also generates a lower revenue increase (75% of that of the benefit cut), but produces much smaller welfare losses, exemplifying the trade-offs involved in policy makers' choice decisions.

The remainder of the paper is organized as follows. We present the model in the next section. The solution method used to solve the model and the HRS data are described in Section 3. The econometric specification and estimation method are discussed in Section 4. The auxiliary statistical model used for the indirect inference estimation procedure is presented in Section 5 and details about the simulation methodology used to implement the procedure are provided in Section 6. Estimation results and model fit are discussed in the following section and counterfactual experiments in Section 8. A brief conclusion is presented in Section 9.

2. Model

The model represents the decision problem of an individual of given gender or a married couple. The optimization problem, consistent with the data available for estimation, begins at a point in the middle of the household's life cycle. Initial conditions are those that prevail at that life cycle point; variation among agents in initial conditions are not explicitly considered until the model's solution and estimation method are discussed.

2.1. Choice set

An unmarried individual of gender j ($j = m, f$) at each discrete age a chooses consumption, C_a^j, and hours worked in the labor market, h_a^j. Hours worked, if positive, are allowed to take on only two values, part-time hours ($h^j = 1$) and full-time hours ($h^j = 2$). In addition, the employment decision is constrained by whether or not the individual worked in the previous period; an individual who was working at age $a - 1$ may choose not to work at age a, to work at age a in the old firm, h^{jo}, or to work in a new firm, h^{jn}. An individual who did not work in the previous period must work, if at all, in a new firm. Employment choices are further restricted in that all individuals are assumed to stop working (permanently) at age A^*. Consumption decisions are made until A.[3] Thus, the choice set at age $a < A^*$ for an individual who worked in the previous period consists of all feasible combinations of C_a^j, h_a^{jo}, h_a^{jn}; for an individual who did not work in the previous period the choice set consists of the feasible combinations of C_a^j, h_a^{jn}.[4] The choice set at age a is denoted by D_a^j and a specific choice within that set by d_a^j. A married couple chooses the consumption and hours of work of each; the choice set is given by $D_a^{mf} = D_a^m \times D_a^f$ and any choice element within the set by d_a^{mf}. Households, singles or couples, are assumed to be able to borrow and lend, and thus may smooth consumption over the life cycle, although net borrowing is restricted (see below). Net assets carried over from a (to $a + 1$), W_{a+1}, is determined residually from the consumption and labor force status decision at a. Consumption, and thus net assets, is treated as continuous.

2.2. Preferences

Each individual of gender j is assumed to have a well-defined preference function over his/her own consumption and labor force status, namely $U_a^j = U^j(C_a^j, h_a^j; M_a^j, Z_a^j, \epsilon_a^{cj}, \epsilon_a^{hj})$ where M is an indicator of marital status, Z is an indicator of health, and the ϵ's are age-varying shocks to the marginal utility of consumption and to hours worked. The marriage decision is not explicitly modeled. The decision model is assumed to pertain only to ages at and beyond some age a_0, from which time it is assumed that an unmarried individual will forever remain single. A married individual may, however, become single after that age due to the death of the spouse, but may not remarry.[5]

2.2.1. Single individuals

An individual who is single at some age a, $a \geq a_0$, having been single up to age a, or having been previously married but currently widowed, maximizes the expected present discounted value of remaining lifetime utility. The time of death is uncertain, although there is a known finite maximum length of life, $a = A$. Individuals are assumed also to obtain utility from bequests. The utility obtained from making a bequest if the individual were to die at age a is $B_{a-1}^j(W_a)$. As the notation indicates, although the bequest actually occurs at a, the utility associated with the bequest is derived while the individual is still alive, at $a - 1$. An individual

[2] The reader should keep in mind that these policy changes are conducted in a partial equilibrium setting on a limited and quite selective subset of the population. Analyzing these changes if they were implemented for the entire population would require careful attention to their effects on different segments of the population and to labor market equilibrium effects on market wages.

[3] In the estimation, we set $A = 90$ and $A^* = 75$.

[4] There are five possible hour combinations in the first case, given that working in a new firm and in an old firm are mutually exclusive alternatives, and three in the second.

[5] We do not allow for divorce. However, divorce rates among individuals over the age of 50 are low. For example, in 1990, the number of divorces per 1000 married individuals aged 50–54 was 12.0 for men and 8.2 for women. For married individuals aged 60–64, the figures were 4.7 and 2.9. (Source: Monthly Vital Statistics Reports, Vol 43 No 9(S), March 1995).

receives utility from the knowledge that a bequest would be made at a if the individual were not to survive past $a-1$.

In the last potential decision period, at age $A-1$, the individual's total utility is therefore $U^j_{A-1}+B^j_{A-1}$.[6] Given the state space at $A-1$, Ω^j_{A-1}, the individual chooses the level of consumption, and thus net assets carried forward, that maximizes this terminal period total utility, i.e., $d^j_{A-1}=d^j_{A-1}(\Omega^j_{A-1})$. Thus, the maximized value of each of the two components of total utility at $A-1$ can be written as a function of the state space. We denote the maximized value of the first component of utility by $G^j_{A-1}(\Omega^j_{A-1})$ and that of the second (bequest) component as $Q^j_{A-1}(\Omega^j_{A-1})$.

At any age a, the maximized expected present value of remaining total lifetime utility given the state space at a, denoted by $V^j_a(\Omega_a)$, is the sum of the maximized expected present values of the remaining utility associated with the two components, $G^j_a(\Omega^j_a)$ and $Q^j_a(\Omega^j_a)$. Note that at age $a<A^*$, the choice set includes labor supply. Each of these components satisfy a Bellman equation, as does their sum. Specifically,

$$\begin{aligned}
V^j_a(\Omega_a) &= G^j_a(\Omega^j_a)+Q^j_a(\Omega^j_a)\\
&=\max_{D^j_a}\Big\{U^j_a(\Omega^j_a)+\delta\pi^{sj}_a E(G^j_{a+1}(\Omega^j_{a+1})|\Omega^j_a, d^j_a(\Omega^j_a))\\
&\quad +(1-\pi^{sj}_a)B^j_a(W_{a+1}(\Omega^j_a))\\
&\quad +\delta\pi^{sj}_a E(Q^j_{a+1}(\Omega^j_{a+1})|\Omega^j_a, d^j_a(\Omega^j_a))\Big\}\\
&=\max_{D^j_a}\Big\{U^j_a(\Omega^j_a)+(1-\pi^{sj}_a)B^j_a(W_{a+1}(\Omega^j_a))\\
&\quad +\delta\pi^{sj}_a E(V^j_{a+1}(\Omega^j_{a+1})|\Omega^j_a, d^j_a(\Omega^j_a))\Big\}, \qquad (1)
\end{aligned}$$

where π^{sj}_a is the one-period survival rate (from a to $a+1$) for a person of gender j and δ is the discount factor.

2.2.2. Married couples

In considering the objective function of married couples, to avoid notational complexity, assume that the husband and wife are of the same age. Then, if each is alive at age $A-1$, the couple chooses consumption levels and hours of work of each to maximize a weighted average of the individual expected values of the remaining lifetime utilities. Specifically, letting θ be the weight placed on the husband's utility,

$$\begin{aligned}
V^{mf}_{A-1}(\Omega^{mf}_{A-1}) = \max_{D^{mf}_{A-1}}\Big[&\theta(\Omega^{mf}_{A-1})\{U^m_{A-1}+B^m_{A-1}\}\\
&+(1-\theta(\Omega^{mf}_{A-1}))\{U^f_{A-1}+B^f_{A-1}\}\Big], \qquad (2)
\end{aligned}$$

where Ω^{mf}_{A-1} denotes the state space for a couple, i.e, the Cartesian product of the individual state spaces. In general, the weight in any period would be, as written, a time-varying function of the current period state space.

In decision periods prior to $A-1$, the couple takes into account the possibility that either or both may not survive into future periods. The expected present discounted value of the couple's remaining lifetime utility is given by

$$\begin{aligned}
V^{mf}_a(\Omega^{mf}_a) = \max_{D^{mf}_a}\Big\{&\theta U^m_a(\Omega^{mf}_a)+(1-\theta)U^f_a(\Omega^{mf}_a)\\
&+\pi^{sf}_a\pi^{sm}_a\delta E(V^{mf}_{a+1}(\Omega^{mf}_{a+1})|\Omega^{mf}_a, d^{mf}_a)\\
&+(1-\pi^{sm}_a)(1-\pi^{sf}_a)\big[\theta B^m_a(W_{a+1}(\Omega^{mf}_a))\\
&+(1-\theta)B^f_a(W_{a+1}(\Omega^{mf}_a))\big]\\
&+(1-\pi^{sm}_a)\pi^{sf}_a\Big[\theta E(Q^m_{a+1}(\Omega^f_{a+1})|\Omega^{mf}_a, d^{mf}_a)\\
&+\ (1-\theta)\delta E(V^f_{a+1}(\Omega^f_{a+1})|\Omega^{mf}_a, d^{mf}_a)\Big]\\
&+(1-\pi^{sf}_a)\pi^{sm}_a\Big[(1-\theta)E(Q^f_{a+1}(\Omega^m_{a+1})|\Omega^{mf}_a, d^{mf}_a)\\
&+\ \theta\delta E(V^m_{a+1}(\Omega^m_{a+1})|\Omega^{mf}_a, d^{mf}_a)\Big]\Big\}, \qquad (3)
\end{aligned}$$

where the argument, Ω^{mf}_a, has been suppressed in θ and in d^{mf}_a for convenience.[7] The value function in (3) is the sum of (i) the share-weighted average of the current individual utilities; (ii) the probability that they both survive times the couple's expected remaining lifetime utility one-period ahead; (iii) the probability that neither the husband nor the wife survives beyond the period times the share-weighted average of their individual utilities from a bequest; (iv) the probability that the wife survives beyond the period but the husband does not, multiplied by the sum of the husband's share times his expected utility of the bequest that the wife will make upon her death (which depends on her future savings decisions) and the wife's share times her expected remaining lifetime utility as a single individual; and (v) the probability that the husband survives beyond the period but the wife does not, multiplied by the sum of the wife's share times her expected utility of the bequest that the husband will make upon his death (which depends on his future savings decisions) and the husband's share times his expected remaining lifetime utility as a single individual.

If the husband and wife are of different ages, the Bellman equations are combinations of (1) and (3). Specifically, if the age difference is k periods, then from the younger spouse's age $A-k$ to age $A-1$, the value function will be that of a single person as in (1). At the younger spouse's age $A-k-1$, when the older spouse is age $A-1$, the value function for the couple will be given by (3) with the survival probability of the older spouse set to zero. In periods prior to the previous one, the value function is given exactly by (3).

2.3. Budget constraint

Define y^j_{ae} to be the amount of labor market earnings at age a of an individual of gender j and y^j_{an} the amount of non-earned income. Labor market earnings is the product of the hourly wage, w^j_a, and hours worked. Net earnings, $\tilde{y}^j_{ae}$, is labor market earnings net of the payroll tax and the income tax. The payroll tax rate is τ^s (=7.65% in 1992) and is applied to earnings up to a maximum of $y^{\max}_e$ (=\$ 55,500 in 1992). Non-labor income at age a is the sum of interest income (payments) on net assets carried over from the previous period, rW_a, where r is the fixed (borrowing and lending) rate of interest, and retirement income from social security, S^j_a, and from a private defined benefit pension on a previous job, P^j_a.[8] Labor earnings, interest income and pension income are also to be taxed at a constant marginal rate, τ (=15%). In addition to a homogeneous consumption good, the budget constraint also

[6] At ages prior to $A-1$, the bequest is multiplied by the probability of not surviving to the next period. At all ages, the bequest is not discounted because, as noted, utility is received during the last period of life.

[7] In (3), the mortality hazards of the husband and wife are assumed independent. Later, we allow them to be correlated through assortative mating on unobservables.

[8] Allowing for pension accrual on a current job with a defined benefit plan or savings associated with a defined contribution plan introduces significant complications in the solution and estimation of the model. As discussed below, we restrict our sample to be consistent with the model.

incorporates expenditures that arise from poor health. Specifically, an individual in poor health at age a, $Z_a^j = 0$, pays a cost of c_z if the individual is not covered by health insurance; an individual in poor health who is covered by health insurance at age a ($hi_a^j > 0$) is assumed to have no out-of-pocket expenses as is a person in good health, $Z_a^j = 1$. Thus, the budget constraint for a single individual of gender j is

$$\begin{aligned} C_a^j + W_{a+1}^j &= \omega_a^j h_a^j [1 - \tau^s - \tau^y][I(\omega_a^j h_a^j \le y_e^{\max})] \\ &+ [(1-\tau^y)\omega_a^j h_a^j - \tau^s y_e^{\max}][I(\omega_a^j h_a^j > y_e^{\max})] \\ &+ (1 + r[1-\tau^y])W_a^j + S_a^j + [1-\tau^y]P_a^j \\ &- c_z[1 - Z_a^j]I(hi_a^j = 0), \end{aligned} \tag{4}$$

where $I(\cdot)$ is an indicator function equal to unity if the expression inside the parentheses is true and zero otherwise. Similarly, the budget constraint for a married couple is

$$\begin{aligned} \sum_j C_a^j + W_{a+1}^{mf} &= \sum_j \tilde{y}_{ae}^j + (1 + r[I - \tau^y])W_a^{mf} + \sum_j S_a^j \\ &+ [1-\tau^y]\sum_j P_a^j - \sum_j c_z[1 - Z_a^j][I(hi_a^m = 0)\cdot I(hi_a^f = 0)]. \end{aligned} \tag{5}$$

Notice that in (5), if either spouse has employer-provided health insurance, the household is assumed to be covered.[9] The individual or couple also faces a borrowing constraint, namely that $W_{a+1} \ge \underline{W}(a+1)$, where the lower bound on net assets is a function of age and may be negative. There is also assumed to exist a publicly (or otherwise) provided guaranteed minimum level of consumption, $\underline{C}$, for a single individual and twice that for a couple. An individual or couple becomes eligible for the transfer if minimum consumption is not feasible after paying off the interest on the debt and enough of the principal to meet the following period's net borrowing constraint.[10]

2.4. Wage offers

Wage offers are the product of a skill rental price, ρ, and an individual's stock of human capital, K.[11] An individual accumulates human capital through general work experience and work experience specific to a job (tenure). The rental price of human capital has a firm-specific component, ϕ, that is constant over tenure within the firm and also differs between part- and full-time employment. The wage offered to an individual is thus

$$\omega_a^j = \rho(h_a^j, \phi)K_a^j(E^j, H_a^j, T_a^j, \epsilon_a^\omega), \tag{6}$$

where E is years of schooling (assumed fixed at the initial age), H_a is cumulative hours worked up to age a, T_a is tenure as measured by the cumulative hours worked for the current employer up to age a and ϵ_a^ω is a random shock to an individual's human capital at age a. As already noted, an individual who is working at $a-1$ receives a wage offer from the same firm as well as an offer from a new firm. The wage offer from the new firm differs from that of the old firm in that tenure is zero at the new firm ($T = 0$), there is a new firm-specific component to the rental price for the individual's human capital stock (ϕ) and a different human capital shock (ϵ_a^ω).

2.5. Social security income

Individuals generally become eligible to apply for social security at age 62. To be eligible for benefits at that age on the basis of one's own employment history requires that the individual has accumulated 40 quarters of covered earnings. In 1992, an individual accumulated one quarter for each \$ 570 of annual earnings (up to a maximum of 4 quarters). Benefits (the primary insurance amount or PIA), given eligibility, depend on an individual's average indexed monthly earnings (AIME) calculated on an annual basis.[12] In calculating this average, there is a maximum amount for covered monthly earnings within a year, \$ 4625 in 1992 (\$ 55,500 annual earnings, the same as is maximum taxable earnings, $y_e^{\max}$), and the lowest five years of indexed earnings are dropped. Given that we observe an individual's AIME only in the middle of the life cycle, in order to avoid having to keep track of the entire history of earnings in updating the AIME from that first observation, it is assumed that the lowest five years of earnings that have already occurred will remain the lowest.[13] The number of computation years used to calculate the AIME is the number of years since turning age 21. Thus, letting e_a be the AIME at age a, the AIME is updated as follows:

$$e_{a+1} = \left[e_a \cdot (a - 21 - 5) + \frac{1}{12}\min(y_{ae}, y_e^{\max}) \right] \Big/ [a + 1 - 21 - 5], \tag{7}$$

where all earnings figures are divided by 12 to reflect the monthly basis of the AIME.

In order to avoid adding another choice variable, we do not model the decision to apply for social security. Instead, it is assumed that all individuals accept social security in the first year in which their benefit net of the earnings tax exceeds 25% of the benefit they would receive if they had zero earnings. Thus, an individual who would receive a social security benefit at age 62 of at least that amount is treated as if the individual had applied for social security at age 62.[14] If the net benefit is less than this amount at age 62, then the benefits obtainable at age 63 are augmented to reflect the actuarial fair adjustment. A similar procedure is followed for all subsequent ages.

Social security benefits are a piece-wise linear function of AIME. Specifically, gross benefits are determined by

$$\begin{aligned} S_{62}^g &= \gamma_0 e_{62} \quad \text{if } e_{62} < b_1, \\ &= \gamma_1 + \gamma_2(e_{62} - b_1) \quad \text{if } b_1 \le e_{62} < b_2, \\ &= \gamma_3 + \gamma_4(e_{62} - b_2) \quad \text{if } b_2 \le e_{62} < b_3, \\ &= \gamma_5 \quad \text{if } b_3 < e_{62}. \end{aligned} \tag{8}$$

Gross benefits are zero if the number of accumulated covered quarters at age 62 is less than 40, $q_{62} < 40$.[15] Earnings above a minimum amount, $\bar{y}$ (=\$ 7440 annually, \$ 620 monthly in 1992), are taxed at a 50% rate, so potential net benefits at age 62 are

$$\begin{aligned} S_{62}^n &= S_{62}^g - .5\max[y_{62,e} - \bar{y}, 0] \quad \text{if } S_{62}^n > 0, \\ &= 0 \quad \text{otherwise}. \end{aligned} \tag{9}$$

9 The treatment of health related factors is obviously simplified. Our purpose is to capture their essential features, while maintaining tractability. Other researchers model health factors in more detail, but compromise on the features related to retirement that we emphasize.

10 An individual or couple for whom minimum consumption is not feasible, according to the above criterion, is relieved of the interest payment in that period as well as that part of the debt necessary to meet the next period's borrowing constraint.

11 Given that ρ is assumed to be constant over time, the implicit assumption is that the labor market is in a steady state equilibrium. Regardless, ρ is taken as given by the individual.

12 The index used to calculate the AIME is based on the national average of total wages.

13 The AIME is obtained from the HRS restricted data.

14 Our treatment of the application decision is unlikely to have a large impact on our estimates. Rust and Phelan (1997), Benitez-Silva and Heiland (2006) and Coile et al. (2002) all find a strong tendency for people to claim benefits upon or shortly after retirement.

15 In 1992, the values of the parameters determining benefits were as follows: $\gamma_0 = .9, \gamma_1 = 348.3, \gamma_2 = .32, \gamma_3 = 971.0, \gamma_4 = .15, \gamma_5 = 1068.8$, and $b_1 = 387, b_2 = 2333, b_3 = 2985$. The latter set of parameters is referred to as bend points.

Gross benefits increase by 6.67% up to age 65 for each year that the age of first receipt of benefits is postponed.[16] After age 65, gross benefits are increased by a variable amount ranging from 5% to 8% depending on the calendar year in which the individual reaches age 62.[17] In addition, the earnings tax is reduced to 33.3% at age 65 and to zero at age 70, and the minimum monthly earnings not subject to tax between age 65 and 69 increases to $ 850.[18]

Married individuals may elect to collect benefits based upon either their own AIME or that of their spouse who is retired. At age 62, the gross benefits available using the spouse's AIME is 37.5% of the spouse's gross benefits. If the age of first receipt is postponed to 63, gross benefits are 41.7% of the spouse's gross benefits, if postponed to 64, 45.8%, and if postponed to 65 or later, 50%.

Widowed individuals can collect on their spouse's earnings record at age 60. At age 60, gross benefits are 71.5% of their spouse's gross benefits, at age 61, 77.2%, and at ages 62 through 65, 82.9%, 88.6%, 94.3%, and 100%. At any time after reaching age 62, a widow(er) may elect to switch to the gross benefits based on their own earnings record.

Given the forward-looking nature of the model, it is necessary to make an assumption about what individuals forecast about future social security rules. We model this uncertainty as a discrete probability distribution over a fixed number of possible proportionate changes in benefits, i.e., proportionate changes in the parameters of the piece-wise linear components, the γ's, of the social security rule (8).[19] Specifically, for any given AIME, benefits are forecasted to change proportionately by 0%, 25%, or 50% with given probabilities. We allow only one change to be forecasted by the individual up to age 62 which will be in place from then on. For a couple, the one change would have to occur by age 62 for the older spouse.[20]

2.6. Mortality risk

Mortality is exogenous in the model, although the risk of mortality at any given age depends on an individual's state of health, sex and age. Specifically, the probability that the individual survives to age $a + 1$ given survival to age a, the survival hazard, is

$$\pi^{sj}_{a+1} = \pi^{s}(Z_a, j, a) \tag{10}$$

for $j = m, f$.

2.7. Health

An individual's state of health is assumed to affect utility directly as in (1) and mortality risk as in (10). As noted, health is assumed to be either good, $Z_a = 1$, or poor, $Z_a = 0$. The probability of being in good health at $a + 1$ is assumed to depend on age, health at age a, and on whether the individual is covered by health insurance, namely

$$\begin{aligned}\pi^{zj}_{a+1} &= \pi^{z}(a+1, Z^j_a, 1 - I(hi^m_a = 0)\cdot I(hi^f_a = 0), j) \quad \text{if married}\\ &= \pi^{z}(a+1, Z^j_a, 1 - I(hi^j_a = 0), j) \quad \text{if single.}\end{aligned} \tag{11}$$

The range of health insurance options is defined next.

2.8. Health insurance

An individual can be covered by health insurance either through a job if one works, through a prior job that provides health insurance upon retirement, or automatically through Medicare upon reaching age 65. We do not allow for the purchase of private health insurance nor do we distinguish between employer-provided insurance versus Medicare in its effect on health. Specifically, health insurance coverage at age a (<65) is categorized as follows: $hi_a = 2$ if the individual currently works or had worked in the past for an employer who provides coverage that continues after retiring from the firm; $hi_a = 1$ if the individual is covered by the employer who does not provide coverage after retiring from the firm; and $hi_a = 0$ if the individual has no coverage.[21]

While at a particular firm, coverage, or lack of it, is assumed to continue without alteration until age 65 at which time Medicare coverage is substituted. We assume that new jobs do not provide coverage upon retirement, i.e., $hi_a \in \{0, 1\}$. A new employer may offer health insurance either only for full-time work or for both full- or part-time work. The probability that a new employer offers health insurance in either case is assumed to depend on the firm-specific component in the wage offer function, namely

$$\pi^{hi}_{a\ |T_a=0} = \pi^{hi}_{a}(\phi). \tag{12}$$

Conditional on receiving an offer from a firm that offers health insurance, the probability that the firm requires full-time work in the first year of employment to receive it is given by $\pi^{hi}_a(\cdot|hi)$.

3. Solution method and data

The model is numerically solved by backward recursion. However, because the state space consists of elements that are continuous variables, e.g., the current level of household assets and the current level(s) of the AIME, it is not possible to obtain "exact" solutions. Instead, we adopt an approximation method due to Keane and Wolpin (1994, 1997).[22]

The data come from the first three waves of the Health and Retirement Study (Juster and Suzman, 1995). The target population for the HRS in the 1992 first wave included all non-institutionalized adults living in a household within the contiguous U.S. born in the years 1931–1941. Spouses of age-eligible individuals residing within the household are also HRS respondents. The HRS includes a representative core sample and oversamples of blacks, Hispanics and Florida residents. A total of 12,652 individuals residing in 7608 households were interviewed in 1992. The same households are re-interviewed every two years. A total of 11,596 individuals in 7227 households were interviewed in 1994 and 10,964 individuals in 6816 households in 1996.

The sample used in the analysis is restricted as follows:

16 If benefits are collected prior to age 65, the reduction in benefits continues past age 65, although it is recalculated at age 65 to account for months in which net benefits were zero. We ignore this recalculation in the model and its associated incentive effects (see Benitez-Silva and Heiland (2006)).

17 An individual reaching age 62 in 1993 or 1994 receives an adjustment to gross benefits of 5%, with the adjustment increasing by.5% for each additional two years up to 8% for individuals reaching age 62 on or after 2005. In the model, we assume a constant, 5.0%, rate for all birth cohorts in order to avoid having to solve the optimization problem separately for each cohort.

18 The earnings tax has recently been eliminated for ages 66 to 69.

19 We assume that the recent change in the earnings test reducing the exemption age to 66 was unanticipated.

20 In the case of a widow(er), if the one change that is permitted in the model has not occurred prior to the spouse's death and the widow(er) is under the age of 62, then the widow(er)'s expectation would be in force until reaching age 62.

21 As reflected in (5) and (11), we assume that the spouse of an individual with coverage is also covered.

22 The details of the solution procedure, including the use of Monte Carlo integration as well the use of splines for approximating the functions are provided in Van der Klaauw and Wolpin (2005). This also includes a description of the state space.

1. Among those who were unmarried at wave 1, those who were married by wave 2 or wave 3 were eliminated. Those women who were unmarried at wave 1 and widowed or divorced after age 44 were eliminated.[23] Among those who were married at wave 1, both household members were eliminated if the couple was divorced by wave 2 or wave 3. We also restricted the sample to couples where the spouse of the HRS respondent was not less than 45 years old at the wave 1 interview.
2. We eliminated all individuals who were ever self-employed (through wave 3); in the case of married couples, both members were eliminated if either was ever self-employed.
3. We eliminated all individuals who ever had defined contribution (DC) pensions; in the case of married couples, both were eliminated if either had a DC plan.[24]
4. We eliminated individuals who are currently working on a job with a DB pension and couples for whom that is the case for either.[25]

The estimation sample contains 230 single males, 363 single females, and 525 couples.[26]

Households are observed for from one to five 12-month periods depending on the number and timing of the interviews in which they participated. Approximately 85% of the households are observed for at least four 12-month periods, with less than 3% observed for 5 periods. Overall, there are 6363 person-periods (4313 household periods).

Table 1 provides descriptive statistics of the state variables at the initial wave for the estimation sample separately by gender and marital status. Single males and females in the HRS must come from the sampled birth cohorts; married males and females may be spouses of HRS respondents outside of the sample birth cohorts. The first number in each cell is the unweighted statistic (mean, percent), the number below in parentheses is the standard deviation and the number below that is the weighted statistic.[27]

4. Estimation method

The model represents the decision process of one household. Differences in the behavior of households with the same initial state variables arise solely due to iid shocks to preferences, shocks to health and health insurance coverage if changing jobs, and shocks to wages (conditional on the employer-specific unobservable for those who are working). However, behaviors tend to be more persistent than can be captured by observable state variables. We, therefore, allow for households to differ in some permanent features that are unobserved by us. Specifically, there are assumed to be a fixed number of types of people who differ parametrically in aspects of preferences and constraints.[28] We provide the exact functional forms when we discuss the parameter estimates of the model.

There are two problems that arise in estimating the behavioral model. First, we observe decisions beginning only in the middle of the life cycle that are, thus, conditioned on state variables that arise from prior decisions. To the extent that those "initial" conditions are not exogenous, e.g., if there is unobserved heterogeneity in preferences or constraints, direct estimation will lead to bias. Second, a substantial number of observations in our sample are missing information necessary to calculate some of the initial state variables and some of the state variables are available only every other year. In particular, initial work experience could not be calculated for 32% of the males and 24% of the females and current job tenure for about 14% of males and 26% of females. In addition, at the first interview, total net assets (non-imputed) is missing for 50%, AIME for 30% and the number of covered quarters for about 24% of the sample.

To account for the "initial" conditions problem, we assume that the probabilities of the unobserved heterogeneity types can be represented by parametric functions of the initial state variables. With shocks to preferences, wages, etc., that are serially independent, the initial state variables are exogenous given type. In the case where observations are missing state variables, calculating choice probabilities (as would enter a likelihood function) would require integrating over the distribution of the missing state variables.[29] To avoid that computational burden, we pursue a non-likelihood-based estimation strategy, indirect inference (see Gourieroux et al. (1993), Gallant and Tauchen (1996), and Gourieroux and Monfort (1996)). The basic idea is to fit simulated data obtained from the behavioral model to an "auxiliary" statistical model that can be easily estimated and that provides a complete enough statistical description of the data to be able to identify the parameters of the behavioral model.

More specifically, we estimate a set of auxiliary statistical relationships with parameters Θ_A. At the ML estimate, $\hat{\Theta}_A$, the score of the likelihood function (L) with respect to the actual data (y_A) must be zero, i.e., $\frac{\partial L}{\partial \Theta_A}(y_A; \hat{\Theta}_A) = 0$. Denoting Θ_B as the parameters of the behavioral model, the idea is to choose parameters that generate simulated data (y_B) that makes the score function as close to zero as possible. This is accomplished by minimizing the weighted squared deviations of the score function evaluated at the simulated data; thus the structural parameters are chosen such that

$$\hat{\Theta}_B = \arg\min_{\Theta_B} \frac{\partial L}{\partial \Theta_A}(y_B(\Theta_B); \hat{\Theta}_A)\, \Lambda\, \frac{\partial L}{\partial \Theta_A}(y_B(\Theta_B); \hat{\Theta}_A). \quad (13)$$

The weighting matrix, Λ, that we have used is a block diagonal matrix, where each of the diagonal matrices is the inverse of the Hessian of an auxiliary model evaluated at the actual data.[30]

[23] The reason for this restriction is that the HRS did not collect social security records for spouses of those who are widowed or divorced. We adopt the implicit assumption that women who are widowed or divorced prior to age 45 will collect social security on their own earnings records.

[24] Allowing for savings from defined contribution plans would require adding another decision variable to the model given their tax-deferred treatment.

[25] Defined benefit plans are very heterogeneous with respect to their accrual rates and retirement age provisions. To incorporate DB plans would require that the model be solved for each individual in the sample with a different plan.

[26] The sample restrictions were made in the following way. The wave 1 sample consists of 12,652 individuals. Of those who were married at the wave 1 interview, 164 were divorced by wave 3. Of the remaining 12,488, 9448 were married at the wave 1 interview, 2281 were single (not married or separated) and the rest were missing data on marital status. Of those who were married, for 2869 couples (5738 individuals), none was ever self-employed. Of the singles, 1826 were never self employed. Only 590 couples and 957 singles, 230 men and 627 women, satisfied the pension requirements of the sample (3 and 4 above). There were 525 couples where neither spouse was under age 45. Of the 627 single women, 363 were either never married, or divorced or widowed prior to age 45.

[27] The weighted figures use the household weights supplied by the HRS. The weighted sample is representative of the population of households in 1992 for which at least one adult comes from the sampled birth cohorts. For a detailed discussion of the construction of the variables listed in Table 1 and of their summary statistics, see Van der Klaauw and Wolpin (2005).

[28] This formulation of unobserved heterogeneity is common in DP models (see, for examples, Wolpin (1984), Van der Klaauw (1995), Keane and Wolpin (1997, 2001) and Eckstein and Wolpin (1999)).

[29] Keane and Wolpin (2001) develop a likelihood simulation-based method of estimation when state variables are missing that circumvents having to perform that integration. The overall complexity of our model and data makes that method burdensome to implement.

[30] Tartari (2006) provide a derivation of the optimal weighting matrix for our case. We did not use the optimal weighting matrix because we were unable to invert the required outer product matrix.

Table 1
Descriptive statistics of initial state variables — estimation sample

	Single		Married	
	Male	Female	Male	Female
Mean age:				
Unweighted	56.2	55.9	59.4	55.2
	(3.2)[a]	(3.3)	(5.9)	(4.5)
Weighted	56.2	55.8	59.5	55.4
% Black:				
Unweighted	37.8	43.3	18.9	18.5
Weighted	23.4	28.7	11.5	11.4
% Hispanic:				
Unweighted	13.5	15.7	19.3	18.1
Weighted	12.4	12.4	13.3	12.3
Mean highest grade completed:				
Unweighted	10.7	10.4	10.3	10.4
	(3.8)	(3.5)	(4.2)	(3.6)
Weighted	11.0	10.7	10.9	10.8
% Ever had a DB pension job:				
Unweighted	34.0	17.3	50.0	23.5
Weighted	37.1	17.4	54.3	24.7
Current pension income (household):				
Unweighted	1615	480	4055	4055
	(4642)	(2603)	(7010)	(7010)
Weighted	2080	437	4601	776
Mean work experience (total hours):				
Unweighted	57,501	41,308	72,963	31,685
	(28,545)	(29,119)	(21,583)	(27,932)
Weighted	57,422	41,768	72,971	31,302
Mean current job Tenure (hours):				
Unweighted	8834	10,225	13,873	8076
	(16,904)	(16,723)	(21,377)	(13,590)
Weighted	10,330	9353	13,380	7539
Mean net assets (no imputations):				
Unweighted	30,067	17,452	114,900	
	(91,944)	(46,098)	(398,056)	
Weighted	34,639	24,084	126,874	
Median net assets (no imputations):				
Unweighted	500	0	30,500	
Weighted	750	35	41,500	
Mean net assets (imputations):				
Unweighted	46,070	30,133	118,853	
	(111,371)	(65,116)	(286,133)	
Weighted	57,098	39,345	132,327	
Median net assets (imputations):				
Unweighted	1850	1000	48,000	
Weighted	5150	1500	56,700	
Mean number of covered quarters:				
Unweighted	93.2	62.2	107.6	55.1
	(40.2)	(43.7)	(45.7)	(39.4)
Weighted	95.1	63.2	110.6	55.8
Mean AIME:				
Unweighted	931	499	1276	390
	(741)	(528)	(864)	(418)
Weighted	1025	504	1363	402
% Poor health:				
Unweighted	51.7	48.2	33.7	32.2
Weighted	47.2	45.3	30.7	29.4
% With employer health insurance:				
Unweighted	16.9	21.4	18.2	11.4
Weighted	20.9	23.6	18.4	11.6
% With employer health insurance when retired:				
Unweighted	7.0	10.1	12.1	6.5
Weighted	8.6	11.9	12.5	6.8
% Never married:				
Unweighted	27.4	19.8	0.0	0.0
Weighted	29.5	17.4	0.0	0.0
% Chance Work Full-Time at Age 62:				
Unweighted	55.1	53.9	57.1	42.8
	(41.0)	(39.6)	(39.6)	(38.6)
Weighted	54.3	54.2	57.4	40.5

Table 1 (*continued*)

	Single		Married	
	Male	Female	Male	Female
% Chance live to age 75:				
Unweighted	51.5	58.8	60.7	61.1
	(35.2)	(35.0)	(33.1)	(30.3)
Weighted	50.4	58.3	60.6	61.3
% Chance live to age 85:				
Unweighted	31.9	44.2	40.4	43.0
	(34.2)	(37.3)	(33.7)	(32.6)
Weighted	31.3	43.2	39.8	42.0
% Chance leave a bequest of $ 10,000:				
Unweighted	36.3	31.5	55.0	49.0
	(44.0)	(42.2)	(43.7)	(43.4)
Weighted	38.9	35.2	56.6	52.7
% Chance leave a bequest of $ 100,000:				
Unweighted	11.6	10.8	25.8	21.1
	(27.6)	(10.8)	(38.0)	(35.7)
Weighted	14.2	13.5	28.5	24.0
Expected social security benefits:				
Unweighted	580	573	691	453
	(237)	(294)	(294)	(228)
Weighted	573	576	704	463
Number of observations	230	363	525	525

[a] Standard deviation in parentheses.

The estimator of Θ_B is consistent when the number of simulated observations grows proportionately with the number of actual observations as the latter goes to infinity.

The auxiliary model that we use in estimation consists of a combination of "approximate" decision rules (that govern the choice variables) and modified structural relationships (such as the health transition function).[31] Obviously, the choice of the auxiliary model is crucial for identification. It is, however, not possible to make a purely constructive identification argument.

5. The auxiliary statistical model

The set of auxiliary models used in estimation are (the number of parameters is in parentheses, including missing value dummies[32])[33]:

1. Multinomial logits of non-employment, full- and part-time employment: There are 29 separate multinomial logits (7 by each of four marital status–gender categories and one for couples only) using alternative sets of variables representing groups of variables such as age, health, social security status, net worth, and work experience (346 score functions).[34] The union of the set of variables included in the specifications comprises: age (linear and age categories), race, education, lagged full-time work dummy, lagged part-time work dummy, cumulative hours worked, cumulative hours of tenure for current employer, health status, lagged health insurance coverage, number of quarters of covered earnings, AIME, amount of current private pension income, lagged net worth, dummy for age greater than or equal to 62 × dummy for social security eligibility, the latter variable × AIME, age of spouse at least 62, dummies for missing values of each of the above variables.
2. Multinomial logit of the transition from employment to non-employment, new or old employer: There are four separate specifications, one for each marital status and sex (34 score functions). The union of the set of variables included in the specifications comprises: age, lagged full-time work dummy, cumulative hours of tenure with current employer, lagged health insurance status, missing value dummies.
3. Regression of net worth: There are three specifications, one each for single males and females, and one for couples (27 score functions). The union of the set of variables included in the specifications comprises: double-lagged net worth, amount of current private pension income, cumulative hours worked, lagged full-time work dummy, lagged health status, race, spouse's education, spouse's AIME, spouse's lagged full-time work dummy, missing value dummies.[35]
4. Regression of log (accepted) wages: Four specifications, one for each marital status–gender category (51 score functions). The union of the set of variables included in the specifications comprises: lagged log wage, education, cumulative hours worked, cumulative hours of tenure, AIME, health status, lagged health insurance status, missing value dummies.
5. Logit regression of receiving versus not receiving health insurance in a new job: Four specifications, one for each marital status–gender category (28 score functions). The union of the set of variables included in the specifications comprises: education, full-time work dummy, AIME, cumulative hours of job tenure on previous job, missing value dummies.

31 See Keane and Wolpin (2000) for a more complete discussion of the formulation of approximate decision rules and for an application.

32 In estimating the approximate decision rules, we included missing value dummy variables for all of the state variables as a means of maintaining sample size.

33 Because the auxiliary models do not represent behaviorally interpretable parameters, we do not present the auxiliary model estimates. They are available on request. For a detailed motivation of these auxiliary models, see Van der Klaauw and Wolpin (2005).

34 We used these separate specifications rather than a single specification including all of the variables because we found the estimation algorithm to be more stable with specifications with smaller numbers of parameters.

35 Net asset stocks are collected at the time of each interview and are thus only available every two years. In the decision model, net worth collected at the 1992 interview is the state variable for 1992 decisions, assets collected at the 1994 interview reflect the 1993 consumption (and saving) decision and also serves as the state variable for 1994 decisions, and assets collected at the 1996 interview reflect 1995 consumption (and saving) and is the state variable for 1996 decisions. Thus, there are two years of asset choices, at the age corresponding to calendar years 1993 and 1995. However, the asset state variables for these choices, assets at the start of 1993 and 1995, are not available, although assets two years prior, at the start of 1992 and 1994, are.

6. Logit regression of health status transition: Four specifications, one for each marital status–gender category (37 score functions). The union of the set of variables included in the specifications comprises: education, AIME, race, cumulative hours of tenure, lagged full-time work dummy, double-lagged health status, missing value dummies.
7. Logit regression of mortality: One specification, marital status–gender categories combined (10 score functions). The variables included are: age, lagged health status, lagged health insurance status, race, dummies for marital status by gender, missing value dummies.
8. Regression of percent chance working full time after age 62: Four specifications, one for each marital status–gender category (45 score functions). The union of the set of variables included in the specifications comprises: education, lagged full-time work and lagged part-time work dummies, cumulative hours worked, cumulative hours of tenure, health status, current private pension income, missing value dummies.[36]
9. Regression of percent chance of leaving a bequest of \$ 10,000, of \$ 100,000: Four specifications, one for each marital status–gender category (59 score functions). The union of the set of variables included in the specifications comprises: lagged net worth, education, AIME, health status, cumulative hours worked, spouse's education, spouse's health status, spouse's AIME, missing value dummies.
10. Regression of percent chance will live to 75, to 85: Four specifications, one for each marital status–gender category (44 score functions). The union of the set of variables included in the specifications comprises: age, health status, race, missing value dummies.
11. Regression of expected social security benefits: Four specifications, one for each marital status–gender category (25 score functions). The union of the set of variables included in the specifications comprises: age expected to receive social security, AIME, cumulative hours worked, health status, missing value dummies.[37]

6. Simulating the data

Having solved the optimization problem, at given parameter values simulating one-step ahead decisions would be straightforward if all of the state variables were observed in each period. For example, consider a hypothetical individual who is 58 years old and unmarried as of the 1992 interview, and who is observed for five 12-month periods, i.e., through age 62. Given the state variables at the 1992 interview, a simulation of the decision at age 58 for that individual would be obtained by drawing a vector of contemporaneous shocks, for preferences, wages, etc., and choosing the alternative with the highest value function. Similar simulations could be obtained at ages 59–62 based on the actual state variables. If, for a particular draw of the mortality shock, the individual was simulated to have died, the simulation of that individual would cease at that point. Net assets at that point would determine the bequest.

A similar procedure would be followed for married couples. Given their ages in 1992, one would simulate the couple's choices based on their observed state space in each period. If one of them died, simulations would then proceed for the survivor as an unmarried individual based on a state space that carries forward their spouse's AIME. The bequest amount would be determined after both die.

However, it is not possible to simulate a decision in a period in which a state variable is missing. If a state variable was missing randomly, one could apply an imputation method, say by drawing a value for the missing state variable from individuals matched according to some set of exogenous characteristics. One would then simulate the decision based on the state variables that are observed and the imputed state variable for that observation. A similar procedure could be followed if several state variables were missing.

This procedure is problematic if state variables are not missing randomly. Table 1 includes statistics on total net assets at the first wave based on complete reports by respondents on all of the components of net assets, and separately, on total net assets that contains values imputed by the HRS for the components that are missing. The median value of the latter was found to be considerably higher than that of the former. To account for biased non-reporting of net assets, the following modified imputation procedure for total net assets, can be used. It is assumed that the actual value of the state variable is given by the imputed value times a bias parameter that is estimated.[38] It is this value of the state variable that is used to simulate the decision. In our implementation, we assume the reporting bias to be zero for all other state variables.[39]

This procedure for simulating data assumes that the population is homogenous with respect to unobservables. As noted, we incorporate unobserved heterogeneity in the model by allowing for a finite number (two) of discrete types of individuals who differ in preferences and constraints. The probability that a simulated individual is a given type depends on the initial state variables, inclusive of imputed values modified for non-random reporting.[40] Given that probability, each simulated observation is identified as a particular type by drawing from the type probability function.

It is useful to explain the procedure with a specific example. Consider a simplified version of the net worth auxiliary model (3 above) in which net worth is regressed only on net worth two periods before; as already noted, net worth is reported only every other year. There are four cases to be considered: (1) net worth is reported at $t-2$ and at t; (2) net worth is reported at $t-2$, but not at t; (3) net worth is not reported at $t-2$, but is reported at t; (4) net worth is not reported at either $t-2$ or at t. The auxiliary model regresses net worth at t on two variables, net worth at $t-2$ and a dummy variable equal to one if net worth is missing at $t-2$ and zero otherwise; where net worth at $t-2$ is set to some arbitrary number, say zero, if it is missing.[41]

36 The error term in percent chance regressions includes classical measurement error. For earlier analyses of the expectations data on employment after age 62 see Honig (1996, 1998).

37 Note that as most individuals in our sample had not yet reached age 62 at the end of the observation period, the subjective expectations data from the HRS on post-age-62 employment, mortality risk, bequests and future social security benefit receipt represent a potentially important source of information for model identification. For example, differences between the reported expected amount of social security and the amount forecasted by the model (given the individual's earnings, employment and savings histories) together will determine expectations about future changes in social security rules.

38 The imputed values are obtained by drawing randomly from groups categorized by age, sex, race, schooling and marital status (as of the first interview). There are 36 groups for unmarried individuals and 54 for married individuals. For any given individual, because of sample size limitations, imputations for each state variable from the set of missing state variables are drawn independently.

39 Also, because so many state variables are missing in 1993 and 1995, we only use the actual (and imputed) state variables for 1992 and 1994. For 1993, we update the 1992 state variables by the 1992 decisions and the 1995 and 1996 state variables by the 1994 and 1995 decisions.

40 Reporting bias for missing state variables is assumed not to vary by type.

41 Clearly, this regression would provide no more information than one which throws out the observations with missing net worth at $t-2$ if there were no other regressors with non-missing values.

In the first case, where net worth is observed at $t-2$, we simulate the choices at $t-1$, including net worth at period $t-1$ (which is not observed in the data), update the state space and simulate the choices at t, including net worth at t. The simulated net worth at t and the observed net worth at $t-2$ enter into the score functions evaluated in Eq. (13). In case 2, because net worth at t was not available to be used in the estimation of the auxiliary model, we do not use this observation (although we do have a simulated value of net worth at t) in (13). In the third case, we impute a net worth value at $t-2$, accounting for potentially biased non-response based on our estimate of the bias, simulate net worth through period t, and treat the observation as it was used in the auxiliary model. That is, we use the simulated value of net worth at t, but treat net worth at $t-2$ as missing. The last case is treated like the second because net worth at t is missing.

Having simulated the data, the criterion function (13) is calculated for each of the auxiliary models.[42] We iterate on the parameters using a simplex algorithm until the sum over the auxiliary models of (13) is minimized. The parameters include those of the behavioral model, those of the type probability function and those defining the bias in missing state variables.

7. Results

7.1. Parameter estimates

The functional forms of the model's structure are provided in Appendix (Eqs. (A.1)–(A.9)). Table A.1 provides parameter estimates and associated standard errors. A number of the parameters are worth highlighting and provide some evidence about the credibility of the model. The coefficient of relative risk aversion $(1-\alpha)$ is estimated to be 1.678 for type 1 individuals and 1.591 for type 2 individuals, within the range of many other findings in the literature.[43] These households are estimated to be severely borrowing constrained. The lower bound on net assets for single households is about −6400 at age 50, falls to −5000 at age 60 and to −2700 at age 75. For married household, the borrowing constraint is slightly less binding, about −7200 for couples who are both 50 and −3100 when they are both 75. Interestingly, we estimate that mean reported assets are 25% lower due to selective non-reporting.

The estimates imply that consumption and leisure are substitutes ($\beta_1 > 0$) and that the marginal utility of consumption increases with good health ($\beta_2 > 0$).[44] In addition, the marginal disutility of hours of work is greater for those in poor health ($\beta_5 > 0$). Transiting from less to more work is costly, that is, the cost of transiting from not working to working part-time is less than transiting to working full-time ($\beta_9 < \beta_8 < 0$) and there is a cost to transiting from part-time to full-time work ($\beta_{12} > 0$). There is also a cost to changing jobs ($\beta_{10} < 0$), although it is significantly smaller than that of labor market entry. The disutility of working is lower for married individuals as the hours worked of the partner increases, that is, the leisure time of couples is complementary.

We restricted the state-space arguments of the Pareto weights to consist of the four combinations of husband and wife types and the difference between the husband's and wife's ages.[45] Type 2 married women are estimated to have considerably less bargaining power than their husbands, while the Pareto weight for type 1 women is close to .5 regardless of the husband's type. In addition, the husband's bargaining power declines as the husband's age increases relative to his wife's age.

With respect to the estimates of the wage offer function, an additional year of schooling increases offered wages by 6.4%, wage offers peak at 54,500 hours of work experience (27 years of full-time work) and at 47,000 hours of tenure (23.5 years of full-time work on the same job) and are 6.8% lower for blacks. We discuss the type-specific differences in wage offers below.

The survival hazard function is estimated primarily from the expectations question about survival chances to age 75 and 85, although recall that a regression of actual deaths is also included among the auxiliary models. Previous work has shown that expectations data on mortality risk are generally consistent with life tables.[46] Because we allow for unobserved heterogeneity in the survival hazard function that is correlated with heterogeneity in other structural components of the model (for example, in the wage offer function) the parameters of the hazard function are jointly estimated with the other parameters of the model. Qualitatively, we find that those in poor health, those without health insurance, males and blacks have higher mortality risk. Moreover, being in poor health together with having no health insurance further heightens mortality risk.

Quantitatively, our estimates of mortality hazards are not very different from life table estimates. Specifically, accounting for the distribution of poor health in our sample, the mortality risk at age 51 for males predicted from our model is .0058, identical to the life table estimate.[47] For males age 61 our prediction is .0139 compared to the life table figure of .0137. While these are remarkably close, the predictions for females are not as good. At age 51 our prediction is .0048 as compared to .0034 in the life table and at age 61, .1029 as compared to .0086.[48] Poor health is predicted to have a large impact on mortality risk. At age 75, men in poor health are predicted to have a mortality rate of .0885, while those in good health have a mortality rate of only .0152. The predictions for females are almost identical; the difference in mortality rates at that age, .048 for men and .031 for women from the life table, would arise solely from the greater incidence of poor health for men than for women. To account for the life table difference, 44.7% of men would have to be in poor health as compared to only 22.2% of women.

In the model, new jobs come with a wage offer, part of which is a firm-specific component, and may also come with a health insurance offer. We modeled the probability of receiving a health insurance offer as depending on an individual's current health and on the firm-specific component of the wage offer. Our estimates imply that the probability of receiving a job offer that includes health insurance (conditional on receiving an offer) is essentially

42 We perform 20 simulations for each sample observation, an individual or a couple, although we only draw a single imputed value for missing state variables.

43 Blau and Gilleskie (2008) report an estimate of 1.81, Rust and Phelan (1997) 1.07, Hurd (1989) 1.12, Blau and Gilleskie (2006) 0.95, French and Jones (2007) 2.97 and French (2005) between 2.2 and 5.1. See also Hubbard et al. (1995).

44 This finding is consistent with the findings of Gilleskie (1998) and Blau and Gilleskie (2006), but differs from that of Rust and Phelan (1997) who found it to be higher in poor health states.

45 Separate identification of the Pareto weights and utility parameters potentially would be problematic, i.e., determined only by functional form assumptions, if the model were estimated solely on married couples. An essential identifying assumption is that utility parameters are the same for both single and married individuals, and so can be recovered from the behavior of singles, an assumption also exploited by Barmby and Smith (2001) and Browning et al. (2006). Although Pareto weights would generally depend on all of the elements of the state space, in order to conserve on parameters, we restricted the arguments of the weights to a few time-invariant elements.

46 See Hurd and McGarry (1995, 2002).

47 We use the Period Life Table, 2000 obtained from the Social Security Administration web site: http://www.ssa.gov/OACT/STATS/table4c6.html

48 We have assumed that poor health occurs in our sample in the same proportion as in the population.

Table 2
Actual and predicted non-employment rates by marital status, gender and age (unweighted (u) and weighted (w) samples)

Age	Married								Single							
	Male				Female				Male				Female			
	NE(u)		NE(w)		NE(u)		NE(w)		NE(u)		NE(w)		NE(u)		NE(w)	
	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.
50–59	38.4[a] (724)	43.7	37.5	42.2	62.8 (1141)	69.0	63.2	70.1	61.9 (514)	60.7	60.1	58.0	54.1 (875)	52.0	51.1	49.3
60–61	51.7 (232)	51.0	53.1	51.7	69.6 (286)	64.2	69.1	65.5	79.1 (148)	70.5	78.5	69.9	69.4 (219)	59.4	66.6	56.7
61–62	59.9 (232)	57.2	60.6	58.2	72.7 (256)	72.5	71.5	73.4	81.1 (127)	75.6	80.3	76.1	73.2 (198)	63.5	71.5	62.8
62–63	66.5 (215)	62.5	66.1	64.1	81.1 (196)	80.9	79.2	81.1	78.2 (87)	78.1	77.7	78.2	76.9 (143)	69.8	75.8	69.5
63-64	71.3 (195)	70.3	70.6	71.4	85.3 (136)	86.0	82.3	86.6	78.7 (47)	79.3	76.2	76.4	76.7 (86)	71.0	73.6	70.6
64–65	75.6 (180)	75.8	75.9	77.2	80.2 (81)	87.2	77.8	87.8	*	–	*	–	78.8 (33)	68.1	74.0	69.8
65–66	75.3 (170)	74.1	75.1	75.5	80.6 (36)	84.7	77.8	83.6	*	–	*	–	*	–	*	–
66+	80.5 (400)	81.7	80.4	81.8	85.7 (21)	80.7	80.1	78.6	*	–	*	–	*	–	*	–

* Indicates less than 25 observations.
[a] Number of person-period observations in parentheses.

Table 3
Actual and predicted full- and part-time employment rates by marital status, gender and age (weighted)

Age	Married								Single							
	Male				Female				Male				Female			
	FT		PT		FT		PT		FT		PT		FT		PT	
	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.	Act.	Pred.
50–59	54.3	50.0	8.2	7.9	23.5	23.9	13.4	6.0	30.2	33.0	9.7	9.1	36.9	33.9	12.0	16.8
60–61	37.1	40.4	9.8	7.8	16.4	21.5	14.5	13.0	17.4	20.1	4.2	10.0	25.5	29.1	7.9	14.1
61–62	28.5	34.6	10.8	7.7	14.5	16.8	13.9	9.8	13.7	14.2	6.0	9.7	19.1	22.6	9.4	14.6
62–63	22.0	25.8	11.9	10.0	9.3	10.8	11.5	8.0	16.3	11.3	6.0	10.5	14.2	16.9	10.1	13.6
63-64	16.2	17.7	13.1	10.8	6.9	9.4	10.8	4.0	22.5	9.0	1.3	14.5	18.0	14.2	8.3	15.2
64–65	11.4	13.1	12.7	9.7	10.7	8.6	11.6	3.6	*	–	*	–	18.4	9.2	7.6	21.0
65–66	12.5	13.0	12.4	11.5	15.4	11.8	6.8	4.7	*	–	*	–	*	–	*	–
66+	7.8	8.9	11.8	9.3	19.9	18.4	0.0	3.0	*	–	*	–	*	–	*	–

* Indicates less than 25 observations.

invariant to the individual's health, .212 in either case.[49] Although positive, the relationship between the firm-specific component of the wage offer and the probability of receiving health insurance is weak and the probability that a health insurance offer requires full-time work is 0.73. In addition, having made job-to-job transitions over their life cycle, those who are currently working have a firm-specific component of their current wage that is on average 29.9% higher than the average firm-specific component of the offer that they would receive from a new firm.

7.2. Model fit

Tables 2–5 provide evidence on the within-sample fit of the model as well as demonstrating other features of the data.[50] These tables use the household weights and, thus, the figures are representative for the population of households with the selected characteristics of our estimation sample.[51]

Table 2 reports non-employment rates by age for each marital status–gender group for the actual data and as predicted by the model, both for weighted and unweighted data. Because in a 12-month period, an individual will usually span two ages (in years), we present the data for those aged 60 and above as two-year moving averages. Although this tends to smooth over abrupt changes, such changes are still generally apparent. For ease of presentation, we group together those aged 50–59 and also those aged 66 and over. It is more salient to concentrate on the weighted data because of their representativeness. Married males have by far the lowest average non-employment rate between ages 50–59, 37.5%, followed by single females at 51.1%, single males at 60.1% and married females at 63.2%. All groups increase their non-employment rates considerably in their 60s. Between age 60–61

49 Dey and Flinn (2005), based on a continuous time model that was estimated with data from the 1996 SIPP find that 75% of wage offers for husbands were accompanied by employer-provided health insurance, while 57% of wage offers for wives were accompanied by wage offers. In their samples of individuals aged 20–54, 80% of husbands and 50% of wives were covered by their own insurance. Our estimate, an offer rate of 21% for both men and women, is considerably lower and corresponds to the much lower coverage rates of the older low-income population represented by our sample (Table 1).

50 In addition to the patterns described here, we also compared actual and predicted statistics for (accepted) full- and part-time wages and for employment transitions by marital status and gender. We also analyzed the model's fit to the expectations data and compared actual and simulated labor supply choices for married and single individuals by several characteristics: whether or not they were receiving income from a private defined benefit pension in 1992, their current health status and their completed education. Overall, the model also captures the patterns in these data reasonably well. The corresponding tables for these analyses can be found in Van der Klaauw and Wolpin (2005).

51 Model predictions are obtained by simulating choices for each single person ten times for each of the two types, and for each married couple five times for each of the four types. In comparing the simulated data sample statistics to the household weighted HRS data, the simulated observations are weighted by the product of their type proportions (to account for using the same number of simulated observations for each type) and the HRS household weights. Figures based on data without household weights are designated as unweighted in the tables.

Table 4
Actual and predicted net assets by marital status and gender (weighted)

	Married				Single			
	Male		Female		Male		Female	
	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
Mean	125,432	120,062	125,432	120,062	44,491	36,674	32,876	25,252
Std. dev.	202,251	196,032	202,251	196,032	106,317	90,092	68,659	65,052
10th percentile	100	−1785	100	−1785	−2200	−5713	−68	−5811
50th percentile	56,500	57,828	56,500	57,828	1650	1732	600	−1595
90th percentile	322,000	303,145	322,000	303,145	153,000	116,284	123,000	93,502
Mean								
Age 50–59	91,174	101,930	114,187	104,069	44,313	33,747	32,813	26,833
Age 60–65	160,472	137,498	151,488	175,741	44,799	41,730	33,032	21,343
Age 66+	137,582	129,512	*	–	*	–	*	–

Table 5
Actual and predicted joint husband and wife employment by age of husband, age of wife 50–59 (weighted)

Husband's age	Neither works		Only husband works		Only wife works		Both work	
	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted
50–59 (659)[a]	24.6	27.8	31.4	49.7	13.7	11.6	30.3	11.0
60–61 (165)	44.1	36.1	28.8	38.7	13.4	12.3	13.8	12.9
61–62 (161)	55.0	43.0	18.9	33.2	14.3	14.8	11.8	9.0
62–63 (148)	61.4	47.0	8.7	28.6	19.5	17.8	10.4	6.6
63-64 (111)	60.2	50.5	9.3	28.4	18.5	16.6	12.0	4.5
64–65 (83)	58.7	59.7	7.5	21.6	20.8	14.4	13.0	4.3
65–66 (76)	55.9	62.2	2.7	19.5	31.3	14.7	10.3	3.7
66+ (185)	68.2	64.4	4.1	16.0	18.9	16.7	8.9	2.8

[a] Number of observations in parentheses.

and age 61–62, the first time some of them reach the social security early retirement age, non-employment rates increase by 7.5% points for married males; similarly, between 61–62 and 62–63, when the rest of the sample also reaches 62, the increase is by 5.5% points. For married and single females, the combined increase between ages 60–61 and 62–63 is 9%–10% points. However, there is essentially no increase for single males, although they had the largest increase between 50–59 and 60–61. The model fits the pattern for these groups reasonably well. For all groups, the model, however, understates the increase between 50–59 and 60–61 and tends to overstate the increase from 60–61 to 62–63. By age 64–65, the model corresponds quite well with the data for married males and single females, but overstates the non-employment rate for married females.

Table 3 breaks down employment rates into full- and part-time. As seen, full-time employment rates decline almost monotonically for married males with age; there is a decline of 15.1% points between ages 60–61 and 62–63.[52] Over the same ages, there is a decline of 7.1% points for married females. The model predictions are declines of 14.6% and 10.7% points. For married males and females, part-time employment rates are roughly constant up to age 61–62 and then increase slightly for married males, while they decline slightly for married females. The model captures the increase for the married males, although not by as much, and captures the decline for females, although it is overstated.

The full-time employment rate for single males follows a u-shape. The model, while picking up the first large decline, predicts its continuation, rather than the increase. Instead, the model predicts a large increase in part-time employment at the last two age intervals. Following a large decline in full-time employment between 50–59 and 60–61, for single females there is a continuing decline through the age of early retirement eligibility and then a leveling off. The model captures this decline. As with single males, the model diverges from the data at the last two age groups, predicting a continued decline and an increase in part-time employment when neither occurs.

It is obviously important that the model capture the major features of the net worth distribution. Table 4 provides statistics on the actual and predicted distributions for married couples and for single men and women. The actual distribution of net worth within each group, as has been well documented and as seen in Table 4, is quite disperse and heavily right-skewed. The mean level of net assets for married males in the weighted sample is $ 125,432, with a standard deviation a bit more than one and a half times that amount and a median value about half that amount. Mean net worth is quite low for single men and women, $ 44,491 for men and $ 32,876 for women. Moreover, the median is only $ 1650 for men and $ 600 for women. The large degree of inequality in net worth is clear from the table. As also shown net worth is higher for older married individuals in this population, but not for older single individuals. Importantly, there are generally only small differences in all marital–gender groups between the distribution of net worth generated by the model and the distribution in the data. The model not only fits well the mean and median, but also the 10th and 90th percentiles, as well as the age pattern.

Table 5 considers the joint labor supply of husband and wives. The table varies the husband's age while keeping the wife's age

52 This decline may capture both life cycle and cohort changes. The upturn in full-time employment rates for married females at ages 64–65 through 66+ would seem to indicate that cohort effects may be important. The model captures cohort effects by allowing type proportions to vary with initial (wave 1) age.

fixed between 50 and 59. Although wives age as the husbands' age increases, the wife's age increase, given the age restriction, is slower so that the age difference increases. The prevalence of couples who both work falls from 30.3% when the husband is between the ages of 50 and 59 to 13.8% when the husband is 60 or 61. The fall in joint employment is almost entirely made up by an increase in the percent of couples in which neither works. The percent of married households in which both work continues to fall gradually with the husband's age, reaching 10.3% for couples in which the husband is 65–66. On the other hand, as the husband ages beyond 60, the percent of households in which only the husband works falls, from 28.8% when the husband is 60–61 to 7.5% when the husband is 64–65. There is a concomitant small rise in the percent of households in which only the wife works, from 13.7% when the husband is 50–59 to 20.8% when the husband is 64–65, but the main shift is towards neither working. The model considerably understates the extent to which both are working when the husband is between 50–59, compensating by overstating the situation in which only the husband works. The model does reasonably well from age 60 on, capturing the overall movement from the situation in which only the husband is working to the one in which neither is working, albeit continuing to overstate the extent to which only husbands work. In the data, the proportion of couples in which only the husband works falls 23 percentage points between 50–59 and 64–65 and by 28 percentage points in the model. Similarly, the rise in proportion of couples in which neither works is almost identical in the data and in the model over these same ages.

Although not specifically related to model fit, Tables 6 and 7 highlight the importance of accounting for unobserved heterogeneity. In the estimation, we allowed for two types for each sex. Thus, single individuals are one of two types, while married couples are of potentially four types. Our estimation reveals interesting differences in behaviors as well as important marital selectivity according to type. We estimate that 49.6% of males in the HRS birth cohort (those of age 51–61 in 1992) are of the sex-specific type 1 (50.4% are of type 2) and 69.5% of women are of the sex-specific type 1 (30.5 are of type 2). As the tables show, there is clearly marital selection by type. For males within the HRS birth cohort, 98.7% of those who are single are type one, while that is true of only 7.2% of those who are married (and married to a female in the HRS cohort). For females, 58.2% of those who are single and 80.6% of those who are married (to males in the HRS cohort) are type 1.[53] Thus, type one males are over-represented and type one females are under-represented among singles.

Among singles, there is little variation in mean schooling levels by type; the difference is only .1 years both for males and females. There is considerably more variation among married couples. Mean schooling of couples in which both are of type one is the highest for both spouses, 11.8 for men and 11.5 for women, and is the lowest for couples in which both are of type 2, 10.9 for men and 10.7 for women. There seems to be positive assortative mating on schooling across the four types. Single men differ only slightly by type in their labor supply, average net worth or average annual consumption. However, they do differ significantly in their annual earnings, which is almost entirely due to the fact that type 1 males receive lower wage offers than do type 2 males; as seen in Table A.1, type 1 males receive a 40% lower wage offer than otherwise identical type 2 males. Single women differ to a greater extent by type than do single men. Only 20.9% of single women of type 1 engage in market work as compared to 84.6% of type 2 women. Because they participate so much less, the annual earnings of type 1 single women are about one-third as large as those of type 2 single women even though the wage offer to otherwise identical type 1 women (independent of marital status) is 37.7% lower (see Table A.1). Type one women work much less because they have a much greater distaste for market work than do type 2 women (see Table A.1).

This distaste for work of type 1 women shows up again among type 1 married women, regardless of the type of their husbands. Only 14.6% of type 1 women work when coupled with type 1 men and only 6.5% work when coupled with type 2 men. About 70% of the husbands of each type work. On the other hand, type 2 married women participate more than their husbands, although these couples comprise only 19.4% of all married couples. These different labor supply patterns of husbands and wives show up in their relative annual earnings as well, with one exception. Husbands earn more than their wives in households where both are of type 2 even though the wives participate about twice as much as their husbands. As with singles, this is due to the lower wage offer received by type two women, who also have a lower disutility of working than do their husbands (see Table A.1).

An interesting pattern in the share of household consumption emerges from our estimates. Type 1 wives, who contribute only a small amount to total household earnings (20% in one case and 6% in the other), share about equally in total household consumption, while type 2 wives, who contribute much more to total earnings (60% in one case and 47% in the other) receive less than a 20% share of total consumption. In addition to type 2 wives having lower disutility from working, as previously noted, type 2 wives have less bargaining power than do type 1 wives.

8. Policy experiments

In this section, we first consider the effects on labor supply and savings of social security reforms that have been suggested as a means of bringing the system into financial balance. In this analysis we focus on a sample of households who would be most at risk from the types of changes in the social security program that have been proposed: households whose members are not currently, or anticipating, collecting on a defined benefit pension plan from a previous job.[54]

We also highlight the impact of those reforms on other related outcomes, such as earnings, consumption, and social security take-up and benefits received. We then consider what would have been the effects on household welfare and social security budget savings for a subset of the reforms, if they had been implemented in 1992.

8.1. Behavioral implications

Tables 8–10 provide estimates of the effect of altering social security program parameters for married couples (Table 8), for single men (Table 9) and for single women (Table 10). Married couples are restricted to those in which both the male and the female fall within the age range 51–61 as of 1992, that is, to those married households in which both are in the HRS cohort. The first column in each table provides the baseline data. The

[53] The figures are only slightly different if we do not restrict the sample to married couples in which both are from the original HRS age cohort. For all married males in the sample, 16.0% are type 1 and for all married females, 79.3%.

[54] Tables reporting the model fit for the no-pension sample (analogous to Tables 2–5 for the estimation sample) are available on request. While there are differences in the means, with net assets being considerably less for individuals in all marital status and gender groups, and with the mean level of schooling being 9.8 for the no-pension subsample, compared to 12.6 for the sample with a prior pension job, the model's ability to fit the data is comparable to that for the estimation sample.

Table 6
Selected characteristics by type — singles

	Females		Males	
	Type 1	Type 2	Type 1	Type 2
Proportion	.582	.418	.987	.013
Highest grade completed	10.7	10.8	11.0	10.9
Not working	.791	.154	.607	.686
Work full time	.151	.567	.284	.291
Annual earnings	3837	11,455	5729	8258
Net worth	20,383	26,038	38,346	38,062
Consumption	6872	9351	9110	9442

effects are shown for two age categories: 51–61 and 62–69.[55] In contrast to the previous tables in which predictions are made only for the estimation sample and condition on state variables observed in 1992 and 1994, these tables forecast behaviors outside of the estimation sample and are conditioned only on 1992 state variables. We will consider each programmatic change in turn, although we first consider the baseline predictions for the two age periods.[56]

8.1.1. Baseline predictions

As seen in Table 8, there is a significant reduction in the participation of both husbands and wives between the ages before and after social security eligibility (age 62); the non-employment rate increases from 27.0% to 48.7% for husbands and from 75.9% to 84.2% for wives. For husbands, the fall in the rate of full-time work is actually larger than the increase in the non-employment rate by about 9% points, reflecting an increase of that amount in the rate of part-time work (from 4.7% to 13.6%). Wives, on the other hand, do not, on average, transit from full-time employment to part-time work after reaching age 62. Overall, average annual hours worked falls by 37% for both husbands and wives, although husbands supply 3 times as many hours as their wives. Husbands take a larger share of total household consumption, 54% in the first age range and 57% in the second, and household consumption is 20% higher in the older than in the younger age range. Income from social security is almost 10,000 for the household. Net assets increase by 74% between the two age ranges.

Single males reduce their participation considerably less after eligibility than do their married counterparts. Indeed, the large fall in full-time employment (from 32.7% to 10.3%) is almost completely offset by the rise in part-time employment (from 10.2% to 31.7%). Overall, however, the fall in average annual hours of 31%, is comparable to married men. Average annual consumption is almost the same in the two age periods and significantly less than the married men. Income from social security is about 5300 dollars per year, about half that of the married households. As with married households, net assets increase substantially over the periods, by 77%, although they are only about one-fifth that of married households.

Single females, as already noted, work more than married females and single men and the change in their labor supply after eligibility is also different. Like both single males and married females, single females reduce their full-time employment substantially (from 40.3% to 24.0%). However, unlike married females, they also increase their part-time employment (from 13.2 to 22.9), but not, as with single males, to the extent that it completely offsets the fall in full-time employment. Overall, the fall in average annual hours, of 24%, is smaller than that of either married females or single males. Average annual consumption is, like single males, almost constant across the periods and is larger than that of married females, although only slightly so in the later age period. Income from social security is about 3000, considerably less than for single men because of a smaller take-up rate (in part because they have a higher full-time employment rate).

Five policy experiments are performed: a reduction in benefits (separately by 25% and 50%), an increase in the employee payroll tax to 15%, the elimination of the earnings tax, eliminating the early retirement age (eligibility begins only at age 65) and raising the eligibility age to 70 (and no early retirement).

8.1.2. Benefit reduction

Married couples: As seen in Table 8, a 25% reduction in benefits slightly reduces participation of both husbands and wives in the 51–61 age range and increases their participation in the 62–69 age range. The change in the latter age range is much larger for husbands than for wives. Full-time employment of husbands increases by 7.4 percentage points, while part-time employment falls by 3.8 percentage points. Overall, average annual hours worked by husbands falls by 29 (2%) over the 51–61 age range, but increases by 116 (13%) over the 62–69 age range. The comparable changes for wives are 15 (3%) and 34 (12%). Due to the changes in their labor supply, the average annual earnings of both spouses decrease when they are 51–61, by 267 dollars for husbands and by 116 dollars for wives, but increase by 1173 dollars for husbands and 169 dollars for wives. The reduction in benefits thus leads to intertemporal substitution in annual hours — given forward-looking behavior, married couples substitute slightly more leisure before eligibility for the reduced leisure after eligibility. The fact that the direction of the effect is the same for both husbands and wives reflects the leisure complementarity implied by our estimated utility parameters.

Average annual consumption for the household, the sum of consumption, falls in both periods, by 414 dollars (2.8%) in the 51–61 age range and by 708 dollars (4.0%) in the 62–69 age range. The fall in household consumption is shared fairly equally between the husband and wife; for example, in the 51–61 age range, the husband's consumption falls by 233 dollars (2.9%) and the wife's by 181 dollars (2.7%). The household's average net assets increases by a negligible amount before eligibility, but falls by 2.2% over the later age range. Thus, after gaining eligibility the household increases its labor supply as well as reduces assets in order to make up for the consumption loss associated with the lower benefits. Although the lower benefits reduce the social security take-up rate by a small fraction, the fall in average monthly social security benefits received by the husband and wife, by 229 dollars or 28.0%, is almost entirely due to the benefit reduction.

All of the effects are magnified with a 50% reduction in benefits. Household labor supply increases by 310 per year (25%) over the 62–69 age range, with a concomitant increase in household earnings of over 3000 dollars (27%). Net asset holdings fall by almost 4000 dollars per year and consumption by 1500 dollars. Average social security benefits fall by over 5000 per year.

Single males: A 25% reduction in benefits reduces participation by 3.1% points in the 51–61 age range, coming both from a reduction in full- and part-time work. There is, surprisingly, also a small reduction in the participation rate in the 62–69 age range (0.2% points). However, there is a shift towards full-time employment leading to an increase in annual average hours worked (from 543 to 588, or 8%), reflecting, as with married couples, intertemporal substitution. Average annual consumption falls in both periods, by a little more in the second (3.8% in the first and 5.7% in the second age period). As with married couples,

55 Married men are on average 57.6 and married women 56.7 years of age in the first age range; they are approximately 8 years older, 65.8 and 64.9, in the second age range. Single men are, on average, 57.9 and 65.3 in the two ranges and single women, 57.8 and 65.4. A table that breaks down the labor supply effect by finer age intervals is available upon request.

56 As in the prior tables, the statistics from the simulations use household weights.

Table 7
Selected characteristics by type — married couples (Both aged 51–61)

	Type 1 Husb. Type 1 Wife	Type 1 Husb. Type 2 Wife	Type 2 Husb. Type 1 Wife	Type 2 Husb. Type 2 Wife
Proportion	.060	.012	.746	.182
Highest grade completed				
Husband	11.7	11.2	11.2	10.9
Wife	11.5	11.1	11.0	10.7
Not working				
Husband	.327	.462	.297	.601
Wife	.854	.214	.935	.275
Both	.288	.108	.277	.165
Work full time				
Husband	.515	.283	.653	.370
Wife	.120	.706	.051	.647
Both	.055	.200	.028	.237
Annual earnings				
Husband	9260	6876	16,100	10,512
Wife	2331	10,458	1047	9262
Total	11,591	17,334	17,147	19,774
Net Worth	110,534	89,029	92,000	77,075
Consumption				
Husband	8586	13,823	7817	12,571
Wife	8642	2819	9246	3049
Total	17,228	16,642	17,062	15,623

Table 8
The effect of counterfactual changes in social security for married couples both aged 51–61 in 1992 with no private pensions

		Baseline		Benefit reduction				Payroll tax		No earnings tax		No benefits			
				25%		50%		Increase to 15%				Until age 65		Until age 70	
	Age[a]	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69
Percent															
NE	H[b]	27.0	48.7	28.5	45.0	28.6	39.5	31.7	55.5	26.5	43.9	25.7	38.6	25.7	32.3
	W	75.9	84.2	76.6	83.0	77.3	81.8	76.2	84.9	75.9	82.3	76.5	83.8	76.5	82.6
FT	H	68.3	37.8	67.1	45.2	67.0	52.3	64.0	30.3	68.7	47.0	69.9	47.3	69.9	58.1
	W	20.7	12.3	19.9	14.1	19.2	16.1	20.1	11.6	20.8	15.8	20.2	15.4	20.2	16.6
PT	H	4.7	13.6	4.4	9.8	4.4	8.3	4.4	14.2	4.8	9.0	4.4	14.1	4.4	9.6
	W	3.4	3.6	3.5	2.6	3.5	2.2	3.7	3.5	3.3	1.9	3.3	0.8	3.3	0.8
Annual Hours	H	1470	927	1441	1043	1439	1173	1376	778	1479	1072	1500	1131	1500	1308
	W	466	292	451	326	436	356	457	278	467	348	455	328	455	353
Consumption	H	8007	10,035	7774	9743	7724	9151	7346	9298	8258	11,072	7945	10,154	7945	9391
	W	6763	7622	6582	7206	6545	7020	6224	6991	6983	8465	6725	7802	6725	6971
Earnings	H	15,630	9372	15,363	10,545	15,422	11,969	14,664	7899	15,732	10,957	15,968	11,321	15,968	13,218
	W	3242	1819	3126	2078	3024	2293	3180	1709	3261	2419	3147	2153	3147	2371
Social Security	H	–	525	–	376	–	240	–	541	–	647	–	473	–	–
Ben. (monthly)	W	–	292	–	212	–	137	–	295	–	327	–	197	–	–
Social Security	H	–	88.4	–	87.3	–	86.2	–	89.8	–	99.4	–	65.7	–	–
Take-up rate	W	–	91.6	–	91.1	–	90.0	–	92.9	–	99.4	–	50.0	–	–
Net Assets		69,752	121,355	69,884	118,726	70,021	117,559	66,290	112,189	68,496	131,191	70,593	117,624	70,593	102,787

[a] Mean ages of husbands and wives are 57.6 and 56.9 in the first age range and 65.8 and 64.9 in the second age range.
[b] H = Husband, W = Wife.

Table 9
The effect of counterfactual changes in social security for single males (No private pensions)

	Baseline		Benefit reduction				Payroll tax		No earnings tax		No benefits			
			25%		50%		Increase to 15%				Until age 65		Until age 70	
Age	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69
Percent														
NE	57.1	58.0	60.2	58.2	63.2	60.1	64.3	69.4	54.3	53.7	55.8	53.6	61.9	57.2
FT	32.7	10.3	30.1	14.8	28.2	25.2	26.8	6.4	34.8	31.9	34.7	33.4	29.1	33.6
PT	10.2	31.7	9.7	26.9	8.7	14.7	8.9	24.2	10.9	14.4	9.6	13.0	9.0	9.1
Annual hours	785	543	728	588	676	677	649	384	837	814	821	830	700	795
Consumption	7146	7420	6875	6996	6645	6756	6683	6868	7350	8078	7128	7635	6884	6910
Earnings	6487	4253	6105	4670	5757	5511	5523	3126	6817	6448	6.790	6717	5960	6617
Social security Ben. (monthly)	–	441	–	320	–	200	–	443	–	471	–	299	–	–
Social security take-up rate	–	87.6	–	87.0	–	86.3	–	88.4	–	92.4	–	54.1	–	–
Net assets	17,993	31,842	18,409	30,593	18,599	30,844	16,281	26,588	17,525	38,995	18,704	33,612	17,748	26,612

Table 10
The effect of counterfactual changes in social security for single females (No private pensions)

	Baseline		Benefit reduction				Payroll tax		No earnings tax		No benefits			
			25%		50%		Increase to 15%				Until age 65		Until age 70	
Age	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69	51–61	62–69
Percent														
NE	46.3	53.1	48.7	52.6	50.6	52.4	50.2	56.6	45.3	48.7	46.7	50.8	51.1	49.1
FT	40.3	24.0	37.5	29.2	35.3	34.3	35.6	17.2	41.7	40.1	39.6	36.9	34.7	42.0
PT	13.3	22.9	13.9	18.2	14.1	13.3	14.2	26.2	12.9	11.2	13.8	12.3	14.3	8.9
Annual hours	977	737	923	797	881	852	888	631	1002	950	966	896	870	966
Consumption	7866	7873	7648	7526	7456	7335	7404	7362	8004	8602	7792	8048	7533	7360
Earnings	8254	6366	7826	6962	7509	7497	7534	5419	8463	8332	8197	7794	7440	8585
Social security Ben. (monthly)	–	264	–	186	–	116	–	227	–	320	–	197	–	–
Social security take-up rate	–	67.3	–	66.2	–	65.5	–	69.0	–	77.8	–	45.5	–	–
Net assets	24,435	38,133	24,169	38,011	24,196	38,273	22,123	31,738	24,092	45,781	24,455	39,187	23,637	35,754

Table 11
The predicted impact of alternative policy interventions on welfare and the social security budget: 1992–2006

	% Δ PDV utility	Δ PDV consumption ($)	Δ total hours worked	Δ SS budget balance		
				Per person ($)	Total per year (in millions $)[a]	
Benefit reduction of 50%						
Single Male	−7.7	−5863	305	1914	35.2	
Single Female	−4.2	−4579	197	1053	39.3	120.0
Married Couple	−8.4	−12,950	1830	4697	45.5	
Increase retirement age to 70						
Single Male	−8.1	−2908	1267	5079	93.5	
Single Female	−5.2	−2365	846	3480	130.0	317.6
Married Couple	−9.8	−8804	3070	9704	94.1	
Increase payroll tax to 15%						
Single Male	−0.1	−4678	−1887	2141	39.4	
Single Female	−0.1	−4944	−1249	3872	144.0	245.0
Married Couple	−1.9	−11,944	−1684	6353	61.6	

[a] Population sizes (based on household weights) are 276,151 for single males, 560,059 for single females and 145,436 for married couples.

average net assets increases in the 51–61 age range (by 2.3%) and falls in the 62–69 age range (by 3.9%). All of these effects are magnified when benefits are reduced by 50% reduction.

Single females: The effect of benefit reduction is qualitatively similar for single females. Intertemporal labor supply effects are present, leading to a near equalization of average annual hours in the two age period when benefits are reduced by 50%. Although consumption falls by more in the second period, the fall in income that occurs from the reduction in benefits, about 1000 dollars for the 25% reduction, is significantly compensated for by the increased earnings.

8.1.3. *Increasing the payroll tax*

Married couples: Raising the payroll tax to 15%, as expected, increases non-employment rates. As with benefit reductions, the effects are larger for husbands. The non-employment rate increases by about 4.7% points for husbands aged 51–61 and by 6.8% points for husbands aged 62–69; average annual hours fall by 94 (6%) in the first age range and by about 149 (16%) in the second. Concomitantly, the household's average annual earnings falls by 5.4% and 15.3%. Household annual average consumption falls by 8.1% at the earlier ages and by 7.7% at the later ages, while average net assets falls by 5.0% and 7.6%. Average social security benefits actually rises, though only by a small amount, because of the higher take-up rate induced by the additional work disincentive.

Single males: The greater disincentive to work caused by raising the payroll tax increases the rate of non-employment for single males even more than for married males. Average annual hours falls by 17.3% in the first age range and by 29.3% in the second, with large percentage falls also in average annual earnings (19.3% and 14.8%). However, average annual consumption declines by less as average net assets falls by 9.5% and 16.5%.

Single females: The labor supply response for single females differs slightly from single and married males in that while non-employment rates rise and full-time employment rates fall, there is also a marked increase in part-time employment and a smaller decline in annual hours overall. All of the other patterns are quite similar.

8.1.4. *Eliminating the earnings tax*

Married couples: Eliminating the earnings tax reduces non-employment, particularly for husbands after reaching age 62. However, there is also a slight increase in employment before age 62 for husbands, although average annual hours is essentially unchanged. After age 62, the full-time employment rate of husbands increases by 9.2 percentage points, while the part-time rate falls by 4.6 percentage points. The overall increase in average annual hours is by 145 (15.6%). And, there is also an increase for wives after age 62, by 56 (19.2%).

Household earnings and consumption both increase slightly in the first period, the latter in small part due to a reduction in net assets (presumably, to smooth consumption). The take-up rate rises essentially to 100%, as eligibility is unaffected by earnings, and there is a considerable increase in average benefits, both because earnings are not taxed and because everyone who is eligible receives benefits. Net assets rise considerably in the second period as some of the extra income is saved.

Single males: The effect on the labor supply pattern of single males is dramatic. Although there is little drop in the non-employment rate after age 62, there is a large shift from part-time to full-time work that is essentially offsetting (by about 20% points), increasing average annual hours by 271 (50.0%). Before age 62, there is a small increase in both part- and full-time work, increasing annual hours by 6.6%. As with married couples, net assets falls slightly in the first period and increases significantly in the second.

Single females: The effect on the labor supply pattern of single females is similar to that of single males, although somewhat less dramatic in that the increase in the full-time employment rate after age 62 is not completely offset by the decline in the part-time employment rate. Average annual hours thus increase by less than for single males, although still substantially (from 737 to 950, 28.9%). All other effects are also quite similar as the other groups.

8.1.5. No benefits until age 65 (eliminating early retirement)[57]

Married couples: Eliminating early retirement increases employment rates of husbands by a small amount before and by a significant amount after age 62. As with the other experiments, there is a much smaller effect on the labor supply of wives. Household earnings and consumption are essentially unchanged in the first period and there is a slight increase in net assets in order to augment consumption in the second period when there are no social security benefits between 62 and 64. The increase in household earnings in the second period and the fall in net assets compensate to leave household consumption essentially unchanged.

Single males: The labor supply response of single males is similar to eliminating the earnings tax. Although the first is obviously welfare improving, they both provide a strong incentive to work after age 62 and the single males again shift from part- to full-time work. The effect on annual hours after age 62 is of the same order of magnitude. The labor response after age 62 is so large that consumption also increases relative to the baseline as does net assets.

Single females: As with males, the response of single females is also similar to the response to eliminating the earnings tax, namely a strong substitution of full-time for part-time work after age 62 and the maintenance of consumption after age 62 at pre-treatment levels.

8.1.6. No benefits until age 70

Married couples: Eliminating all benefits until age 70 has essentially no additional impact on behaviors before age 62 above that of eliminating benefits until age 65 in the previous experiment. However, the effects after age 62 are different and not monotonic with respect to the previous experiment. Although non-employment rates continue to fall and full-time employment rates are higher for husbands and wives relative to the previous experiment, part-time employment rates of husbands fall. And, while consumption rose after age 62 in the previous experiment, eliminating benefits up to age 70 reduces consumption relative to the baseline even though net assets falls by an additional large amount (from 117,624 in the previous experiment to 102,787).

Single males: For single males, there are further effects on behaviors before age 62 of eliminating benefits up to age 70 beyond those of the previous experiment. Annual hours and earnings fall even further. After age 62, again effects are not monotonic. Annual hours and earnings, though larger than in the baseline, are smaller than in the previous experiment. Consumption also falls after age 62 as does net assets, although they both rose relative to the baseline in the previous experiment. The elimination of the social security benefits that would otherwise be received is too large for an optimal labor supply adjustment to compensate so as to maintain consumption and savings levels.

Single females: The effect on single females mirrors the effect on single males.

8.2. Budget and welfare implications

Table 11 illustrates the trade-off, for three of the policy reforms, between the welfare losses that would be suffered by the individuals in the no-pension sample and the increase in net revenues to the social security fund. The policy is assumed to have been implemented in 1992, with their impacts calculated over the following 15 years, through 2006.[58] We consider a reduction in benefits of 50%, an increase in the retirement age to 70 and an increase in the payroll tax to 15%. The first column in Table 11 shows the (population-weighted) average percentage fall in the present discounted value of utility over the 1992–2006 period due to each policy change. These welfare losses are presented separately for single males, single females and for married couples (the level of the utility of couples at any period is the sum of the utilities of husbands and wives who are still alive). We present also the corresponding dollar changes in the present discounted value of consumption and in total hours worked over the same period. The fourth column presents the change in the average net social security revenue over the period, that is, the payments into social security through the payroll tax minus social security benefits (taking into account the earnings tax). Finally, we show in column five the change in the per-year net social security revenue for the population corresponding to our sample.

Consider first the impact of these policy changes on welfare. The fall in the present value of utility due to a 50% reduction in benefits is estimated to be 7.7% for single males, 4.4% for single women and 8.4% for married couples. The effects of increasing the retirement age to 70 are of similar magnitudes: a fall of 8.1% for single males, 5.2% for single females and 9.8% for married couples. The effect of these policy changes on welfare are considerably larger than the effect of the 15% increase in the payroll tax: the corresponding losses are .1, .1, and 1.9%. The compositional effects of these policy changes, in terms of changes in the optimal choice of consumption and hours worked, differ. In particular, all three policy changes induce a fall in consumption, and of reasonably similar magnitudes. However, although the benefit reduction and increased retirement age lead to an increase in hours worked, a larger increase for the first than for the second policy change, the increased payroll tax leads to a significant reduction in hours worked. This (optimal) reduction in hours worked accounts for the much smaller drop in welfare from this policy. What is taken to be the measure of welfare, utility or consumption, is thus important in considering the welfare impact of these alternative policies.

The last column in the table shows the effect of each policy on the social security budget balance. In all cases, these policies generate positive net revenues. However, there is a clear ordering. Reducing the social security benefit by 50% would have increased net revenues by $ 120 million, the increase in the payroll tax to 15% by $ 245 million and the increase in the retirement age by $ 318 million. Given the estimated welfare losses associated with these changes, reducing the benefit by 50% would be the least efficacious policy change. However, there is a marked trade-off between the other two policies. The 30% larger increase in net revenues associated with the increased retirement age relative to

[57] Increasing the early or normal retirement age would possibly lead to an increase in filings for disability. The evidence in the literature is mixed. Bound et al. (2004) conclude that increasing the normal retirement age to 67 (while correspondingly reducing benefits at all early retirement ages) would have essentially no effect on the DI application rate of single men. On the other hand, Duggan et al. (2007) estimate that the 1983 reform in which the normal retirement age was increased to 67 caused significant increases in DI enrollment of 0.6% points for men and 0.9% points for women aged 45–64 in 2005. Although these changes represent large proportional increases in DI enrollment rates, they are nevertheless small when compared to the large policy-induced employment and hour responses predicted by our model.

[58] Over the 15 years, average survival in the baseline simulation is 12.9 for single males, 13.1 for single females and 14.6 for the longest living spouse of a married couple.

the increased payroll tax is gained at the expense of a considerably larger fall in welfare. Thus, a policymaker would have to weigh the trade-off in choosing among these two policy changes.

There are a number of important caveats to this analysis. With respect to the payroll tax increase, both the welfare losses and the revenue gains would be considerably larger for a population that consisted of younger individuals who faced longer working lives. Without solving the model back to earlier ages, which is beyond the scope of the present enterprise, it is not possible to tell how much welfare would fall nor how much net revenues would increase. In addition, all of the policy effects would be different, even calculated only over the ages of the sample, if the policy had been in effect at earlier ages. Policy effects would be different because households would have arrived at the sample ages in 1992 with different levels of their state variables (assets, work experience). Because of the special nature of the sample and these caveats, these results should be taken as being illustrative of the kind of trade-offs of which policymakers need to be cognizant when modifying the current social security system.

9. Conclusions

In this paper, we have specified and estimated a dynamic model of retirement and savings decisions for a low-income subsample of households from the Health and Retirement Study. The model incorporated a discrete employment decision (non-employment, part-or full-time employment) and a continuous consumption decision for both unmarried men and women and for married couples. Additional features of the model included a detailed specification of social security rules, limited borrowing, probabilistic job offers from new firms specifying the wage and health insurance availability, a bequest motive, uncertain health and survival, wages that evolve with labor market experience and job tenure, and unobserved heterogeneity in preferences, wages and health status. The model was estimated using the method of indirect inference. The estimated model was shown to reasonably fit many different aspect of the data.

The model was used to understand the impact of changes in social security rules on household labor supply, income and consumption. The estimated model forecasts large and heterogeneous behavioral responses, with those of singles generally exceeding those of married individuals, and those of husbands being considerably larger than those of wives. In the case of a reduction in social security benefits of 25%, we find moderately large reductions in labor supply at ages below 62 (2%–3% for married, 5%–7% for singles), and large increases in annual hours worked at ages 62–69 (12% for married, 8% for singles). Increasing the social security payroll tax to 15%, a large change in itself, is predicted to lead to considerable reductions in annual hours worked at all ages, with average annual hours of working at ages 62–69 falling by 5% for wives, 14% for single women, 16% for husbands, and 29% for single males, with similar but somewhat smaller reductions at ages 51–61. These reductions take the form of increases in both non-employment and in part-time work, except for single males for whom the part-time rate drops.

We find qualitatively similar responses in labor supply to the removal of the earnings test, the elimination of early retirement, and a postponement of the earliest retirement age to 70. In all cases, we predict sharp increases in average annual hours of work (with estimates varying between 16% and 52%) and in full-time employment at ages 62–69. For couples most of this is due to a reduction in non-employment, while for singles it is primarily due to a shift from part-time into full-time employment. Again, we find smaller changes in the labor supply of wives compared to that of husbands, and somewhat smaller (although still substantial) increases for single women compared to single men. The policy changes have very little effect on the labor supply of married individuals at ages below 62, but this is not the case for singles for whom we predict varying positive and negative responses in labor supply that depend on the exact nature of the policy change. For example, removal of the work disincentives embedded in the earnings test leads to a 6.6 (2.6)% increase in annual hours of work for single males (females) at ages 51–61, but has a negligible impact on the labor supply of married couples in that age group.

Overall, the counterfactual experiments indicate that the changes in the social security rules we consider would lead to large behavioral responses in the work behavior of low-income households, which in turn would have a substantial financial impact on the social security system. At the same time, we found the employment responses to these policy changes to be accompanied by modest, but not inconsequential, changes in net assets holding, indicating that both labor supply and savings decisions play important roles in mitigating the consequences for consumption and welfare of benefit reductions and of the elimination or postponement of the early and normal retirement age.

The policy experiments also illustrate the existence of potentially important trade-offs faced by policy makers in balancing consumer welfare losses against revenue increases. We find that if the government had reduced social security benefits by 50% in 1992, the welfare (present discounted utility flow) loss to the population represented by the no-pension sample would have ranged from 4% for single females to 8% for married couples. The welfare loss would have been of a similar magnitude if the retirement age had been increased to 70 in 1992. However, the net revenue gain associated with the benefit reduction would have been only about 40% as large as that from the increased retirement age. In contrast, the welfare loss from increasing the payroll tax to 15% would have resulted in less than a 2% fall in welfare and an increase in net revenues that was about 75% as large as that from the increased retirement age. Thus, while a policymaker would necessarily have preferred either of the latter two policies, the choice between them would depend on how the larger net revenue obtained from one policy is weighed against its greater welfare loss.

Acknowledgements

We are grateful for support from the National Institute on Aging grant AG14862. The views and opinions offered in this article do not necessarily reflect those of the Federal Reserve Bank of New York or the Federal Reserve System as a whole. We thank the two anonymous referees for their extensive and helpful comments.

Appendix

Utility function:

$$\begin{aligned}
u_a = {} & \frac{C_a^{\sum_{j=1}^{2}\alpha_j I(\text{type}=j)}}{\sum_{j=1}^{2}\alpha_j I(\text{type}=j)}[1+\exp(\beta_1 h_a^* + \beta_2 Z_a + \epsilon_a^c)] \\
& + h_a^* \sum_{j=1}^{2}[(\beta_{j+2} I(\text{type}=j) + \beta_{j+2,f} I(\text{type}=j, \text{sex}=f)) \\
& + \beta_5 Z_a + \beta_6 D_r + \epsilon_a^h] + \beta_7 Z_a + \beta_8 I(h_a=1) I(h_{a-1}=0) \\
& + \beta_9 I(h_a=2) I(h_{a-1}=0) \\
& + \beta_{10} I(h_a^n > 0) I(h_{a-1} > 0) + \beta_{11} I(h_a^o = 1) I(h_{a-1}=2) \\
& + \beta_{12} I(h_a^o = 2) I(h_{a-1}=1) + \beta_{13} h_a^{m*} h_a^{f*} D_m \qquad \text{(A.1)}
\end{aligned}$$

Table A.1
Parameter estimates

Utility function	Estimate (S.E.)	Pareto weights	Estimate (S.E.)	Wage function	Estimate (S.E.)
α_1	−.678 (1.61E−04)	θ_1	1.11E−02 (3.78E−03)	ω_1	0.603 (2.74E−03)
α_2	−.591 (2.25E−04)	θ_2	−4.70E−03 (1.29E−03)	ω_2	1.02 (3.99E−04)
β_1	1.73E−04 (5.0E−06)	θ_3	−0.994 (3.40E−03)	ω_{1f}	0.102 (3.70E−05)
β_2	9.99E−02 (1.22E−04)	θ_4	−1.01 (1.95E−03)	ω_{2f}	−0.275 (6.70E−05)
β_3	14.0 (6.53E−03)	θ_5	−2.21E−04 (4.60E−05)	ω_3	−0.100 (6.22E−04)
β_{3f}	−9.37 (9.33E−03)	θ_6	−5.74E−05 (2.50E−05)	ω_4	4.55E−03 (1.31E−04)
β_4	−25.1 (1.93E−03)			ω_5	4.34E−05 (3.00E−06)
β_{4f}	23.2 (1.36E−03)			ω_6	5.72E−03 (2.40E−05)
β_5	0.101 (.019)			ω_7	6.33E−05 (2.00E−06)
β_6	−6.82E−02 (.507)			ω_8	0.064 (3.70E−05)
β_7	−2.15E−02 (.160)			ω_9	−0.068 (1.09E−04)
β_8	37.7 (.034)				
β_9	−58.9 (.036)				
β_{10}	−10.5 (.020)				
β_{11}	9.83E−03 (.062)				
β_{12}	−53.4 (1.02)				
β_{13}	1.03E−02 (3.62E−03)				
γ_{1m}	1.74 (5.50E−04)				
γ_{2m}	1.26 (7.52E−04)				
γ_{1f}	1.46 (1.12E−03)				
γ_{2f}	5.60 (7.01E−03)				

Survival hazard function	Estimate (S.E.)	Health transition function (to good health)	Estimate (S.E.)	Health insurance offer rate	Estimate (S.E.)
π_0^s	−8.28 (1.34E−03)	π_0^h	1.36 (3.46E−04)	π_0^{hi}	1.31 (3.35E−03)
π_1^s	−8.68E−05 (.022)	π_1^h	.017 (1.42E−03)	π_1^{hi}	1.17E−03 (.010)
π_2^s	.079 (1.60E−05)	π_2^h	5.94E−03 (6.00E−06)	π_2^{hi}	−.050 (3.83E−03)
π_3^s	−1.84 (1.86E−03)	π_3^h	−2.54 (7.58E−04)	π_3^{hi}	1.01 (1.09E−04)
π_4^s	−1.53E−03 (3.80E−04)	π_4^h	−0.652 (2.76E−04)		
π_5^s	1.86E−03 (6.94E−04)	π_5^h	0.919 (1.38E−03)		
π_6^s	1.90E−03 (5.45E−04)	π_6^h	0.015 (1.28E−03)		
π_7^s	−1.87E−03 (6.00E−06)	π_7^h	−3.05E−03 (2.00E−06)		
π_8^s	2.73E−05 (5.71E−04)	π_8^h	0.384 (4.00E−04)		

Type probability function	Estimate (S.E.)	Net asset lower bound	Estimate (S.E.)	Error standard deviations	Estimate (S.E.)
π_0^p	−2.24 (.202)	$\underline{W}_s$	−25.1 (.014)	ε^c	0.996 (2.28E−04)
π_1^p	.014 (6.32E−03)	ξ_s	7.21E−03 (5.00E−06)	ε^h	0.335 (5.48E−03)
π_2^p	1.85E−07 (8.40E−05)	$\underline{W}_c$	−25.0 (.112)	Current job ε^w	0.248 (2.30E−04)
π_3^p	−4.021 (.202)	ξ_m	4.15E−03 (4.00E−06)	New job ε^c	0.251 (2.28E−04)
π_4^p	0.116 (9.03E−04)	ξ_f	4.13E−03 (2.20E−05)		
π_5^p	1.44E−03 (.022)				
π_6^p	0.010 (5.16E−04)				
π_7^p	0.513 (6.64E−03)				
π_8^p	−5.86 (.203)				

Measurement Error	Estimate (S.E.)	Miscellaneous	Estimate (S.E.)	Fixed Parameter	Estimate
S.D Wage	0.401 (3.20E−04)	c_z	2,165 (1.02)	δ	0.95
S.D. Assets	0.547 (8.36E−04)			r	0.05
Percent bias in imputed assets	0.249 (1.28E−03)	Prob. of decline in social security benefits is:		$C_{\min}$	4,000
		0%	1.00		
		25%	0.00		
		50%	0.00		
		Mean Initial Period ϕ	0.299 (2.65E−04)		
		S.D ϕ	0.200 (3.78E−03)		
		ψ_1	0.713 (3.55E−04)		

H, T measured in units of 520 h.

where

$$h_a^* = I(h_a = 1) + \sum_{j=1}^{2}\sum_k \gamma_{jk} I(\text{type} = j, \text{sex} = k) I(h_a = 2),$$

$h_a^{k*} = h_a^* I(\text{sex} = k)$,
$h_a^n =$ hours if new job; $h_a^o =$ hours if old job;
$D_r = 1$ if race is black; $= 0$ otherwise,
$D_m = 1$ if married, $= 0$ if single.

Pareto weights:

$$\begin{aligned}\theta_m &= [1 + \exp(\theta_1 I(\text{type}_m = 1, \text{type}_f = 1) \\ &\quad + \theta_2 I(\text{type}_m = 2, \text{type}_f = 1) \\ &\quad + \theta_3 I(\text{type}_m = 1, \text{type}_f = 2) \\ &\quad + \theta_4 I(\text{type}_m = 2, \text{type}_f = 2) + \theta_5 (a_m - a_f) \\ &\quad + \theta_6 (a_m - a_f)^2)]^{-1} \\ \theta_f &= 1 - \theta_m, \end{aligned} \tag{A.2}$$

where $\text{type}_m =$ husband type, $\text{type}_f =$ wife type, $a_m =$ age of husband, $a_f =$ age of wife.

Bequest function:

$$B_a(W_{a+1}) = \Psi_1 W_{a+1}. \tag{A.3}$$

Wage function:

$$\begin{aligned}\log w_a &= \sum_{j=1}^{2} (\omega_j I(\text{type} = j) + \omega_{j,f} I(\text{type} = j, \text{sex} = f)) \\ &\quad + \omega_3 I(h_a = 1) + \omega_4 H_a - 0.5\omega_5 H_a^2 \\ &\quad + \omega_6 T_a - 0.5\omega_7 T_a^2 + \omega_8 E + \omega_9 D_r + \phi + \epsilon_a^w. \end{aligned} \tag{A.4}$$

Survival hazard function:

$$\begin{aligned}\pi_a^s &= [1 + \exp(\pi_0^s + \pi_1^s I(\text{type} = 2) + \pi_2^s a + \pi_3^s Z_{a-1} \\ &\quad + \pi_4^s I(hi_a > 0) + \pi_5^s (1 - Z_{a-1})(1 - I(hi_a > 0)) \\ &\quad + \pi_6^s I(\text{sex} = f) + \pi_7^s a I(\text{sex} = f) + \pi_8^s D_r)]^{-1}. \end{aligned} \tag{A.5}$$

Health transition function:

$$\begin{aligned}\pi_a^h &= [1 + \exp(\pi_0^h + \pi_1^h I(\text{type} = 2) + \pi_2^h a + \pi_3^s Z_{a-1} \\ &\quad + \pi_4^h I(hi_a > 0) + \pi_5^h (1 - Z_{a-1})(1 - I(hi_a > 0)) \\ &\quad + \pi_6^h I(\text{sex} = f) + \pi_7^h a I(\text{sex} = f) + \pi_8^h D_r)]^{-1}. \end{aligned} \tag{A.6}$$

Health insurance offer function:

$$\begin{aligned}&\Pr(hi_a = 1) = \pi_a^{hi} = [1 + \exp(\pi_0^{hi} + \pi_1^{hi} Z_a + \pi_2^{hi} \Phi)]^{-1} \\ &\Pr(h_a = 2 \text{ isn't required} | hi \text{ offered}) = [1 + \exp(\pi_3^{hi})]^{-1}. \end{aligned} \tag{A.7}$$

Type probability function:

$$\begin{aligned}\Pr(\text{type} = 2) &= \pi_0^p + \pi_1^p W_{a_0} + \pi_2^p H_{a_0} + \pi_3^p I(\text{sex} = f) \\ &\quad + \pi_4^p a + \pi_5^p D_r + \pi_6^p E \\ &\quad + \pi_7^p D_m I(\text{sex} = f) + \pi_8^p D_m I(\text{sex} = m). \end{aligned} \tag{A.8}$$

Net assets constraint:

$$\begin{aligned} W_a &\geq \underline{W}_s [1 - \exp(-\xi_s (91 - a_j))] \quad j = m, f; \text{ singles} \\ W_a &\geq \underline{W}_c [1 - \exp(-\xi_m (91 - a_m) - \xi_f (91 - a_f))]; \\ &\quad \text{couples.} \end{aligned} \tag{A.9}$$

References

Barmby, T., Smith, N., 2001. Household labour supply in Britain and Denmark. Applied Economics 33, 1109–1116.
Benitez-Silva, H., Heiland, F., 2006. Early claiming of social security benefits and labor supply behavior of older Americans. Mimeo. SUNY Stony Brook.
Berkovec, J., Stern, S., 1991. Job exit behavior of older men. Econometrica 59, 189–210.
Bernheim, B.D., Levin, L., 1989. Social security and personal savings: An analysis of expectations. American Economic Review 79, 97–102.
Blau, D.M., 1994. Labor force dynamics of older men. Econometrica 62, 117–156.
Blau, D.M., Gilleskie, D.B., 2008. The role of retiree health insurance in the employment behavior of older men. International Economic Review 49 (2), 475–514.
Blau, D.M., Gilleskie, D.B., 2006. Health insurance and retirement of married couples. Journal of Applied Econometrics 21, 935–953.
Bound, J., Stinebrickner, T., Waidmann, T., 2004. Using a structural retirement model to simulate the effect of changes to the OASDI and medicare programs, wp091, University of Michigan, Michigan Retirement Research Center.
Browning, M., Chiappori, P., Lewbel, A., 2006. Estimating consumption economies of scale, adult equivalence scales, and household bargaining power. Mimeo. Boston College.
Coile, C., Diamond, P., Gruber, J., Jousten, A., 2002. Delays in claiming social security benefits. Journal of Public Economics 357–386.
Dey, M., Flinn, C., 2005. An equilibrium model of health insurance and wage determination. Econometrica 73, 571–628.
Diamond, P.A., Hausman, J.A., 1984. Individual retirement and savings behavior. Journal of Public Economics 23, 81–114.
Dominitz, J., Manski, C.F., Heinz, J., 2003. Will social security be there for you?: How Americans perceive their benefits. NBER 9798.
Duggan, M., Singleton, P., Song, J., 2007. Aching to retire? The rise in the full retirement age and its impact on the disability rolls. Journal of Public Economics 91, 1327–1350.
Eckstein, Z., Wolpin, K.I., 1999. Why youths drop out of high school: The impact of preferences, opportunities, and abilities. Econometrica 67, 1295–1339.
Feldstein, M.S., 1974. Social security, induced retirement, an aggregate capital accumulation. Journal of Political Economy 84, 905–926.
Fields, G., Mitchell, O., 1984. Retirement, Pensions, and Social Security. The MIT Press, Cambridge.
French, E., Jones, J.B., 2007. The effects of health insurance and self-insurance on retirement behavior. Federal Reserve Bank of Chicago, WP 2001-19.
French, E., 2005. The effects of health, wealth, and wages on labour supply and retirement behaviour. Review of Economic Studies 72, 395–427.
Gallant, A.R., Tauchen, G., 1996. Which moments to match? Econometric Theory 12, 657–681.
Gilleskie, D., 1998. A dynamic stochastic model of medical care and work absence. Econometrica 66, 1–46.
Gourieroux, C., Monfort, A., 1996. Simulation-Based Econometric Methods. Oxford University Press, Oxford.
Gourieroux, C., Monfort, A., Renault, E., 1993. Indirect inference. Journal of Applied Econometrics 8, S85–S118.
Gustman, A.L., Steinmeier, T.L., 1986. A structural retirement model. Econometrica 54, 555–584.
Gustman, A.L., Steinmeier, T.L., 1994. Employer-provided health insurance and retirement behavior. Industrial and Labor Relations Review 48, 124–140.
Gustman, A.L., Steinmeier, T.L., 2000. Retirement in a family context: A structural model for husbands and wives. Journal of Labor Economics 18, 503–545.
Gustman, A.L., Steinmeier, T.L., 2005. The social security early entitlement age in a structural model of retirement and wealth. Journal of Public Economics 89, 441–463.
Honig, M., 1996. Retirement expectations by race, ethnicity and gender. The Gerontologist 36.
Honig, M., 1998. Married women's retirement expectations: Do pensions and social security matter? American Economic Review Papers and Proceedings 88, 202–206.
Hubbard, G., Skinner, J., Zeldes, S., 1995. Precautionary saving and social insurance. Journal of Political Economy 105, 360–399.
Hurd, M., 1989. Mortality risks and bequests. Econometrica 57, 779–814.
Hurd, M.D., McGarry, K., 1995. Evaluation of the subjective probabilities of survival in the health and retirement study. Journal of Human Resources 30, S268–S292.
Hurd, M.D., McGarry, K., 2002. The predictive validity of subjective probabilities of survival. The Economic Journal 112, 966–985.
Juster, F.T., Suzman, R., 1995. An overview of the health and retirement study. Journal of Human Resources S7–S56.
Keane, M., Wolpin, K.I., 1994. The solution and estimation of discrete choice dynamic programming models by simulation and estimation: Monte Carlo evidence. Review of Economics and Statistics 76, 648–672.
Keane, M., Wolpin, K.I., 1997. The career decisions of young men. Journal of Political Economy 105, 473–522.
Keane, M., Wolpin, K.I., 2000. Equalizing race differences in school attainment and labor market success. Journal of Labor Economics 18, 614–652.
Keane, M., Wolpin, K.I., 2001. The effect of parental transfers and borrowing constraints on educational attainment. International Economic Review 42, 1051–1103.
Lumsdaine, R., Stock, J.H., Wise, D.A., 1992. Three models of retirement: Computational complexity vs. predictive validity. In: Wise, D. (Ed.), Topics in the Economics of Aging. University of Chicago Press, Chicago.

Lumsdaine, R., Stock, J.H., Wise, D.A., 1994. Pension plan provisions and retirement: Men and women, medicare and models. In: Wise, D.A. (Ed.), Studies in the Economics of Aging. University of Chicago Press, Chicago.
Lumsdaine, R., Stock, J.H., Wise, D.A., 1996. Why are retirement rates so high at age 65? In: Wise, D.A. (Ed.), Advances in the Economics of Aging. Chicago University Press, Chicago.
Moffitt, R.A., 1987. Life-cycle labor supply and social security: A time series analysis. In: Burtless, G. (Ed.), Work, Health and Income Among the Elderly. The Brookings Institution, Washington, DC.
Phelan, C., Rust, J., 1991. U.S. social security policy: A dynamic analysis of incentives and self-selection. Mimeo. University of Wisconsin.
Rust, J., Buchinsky, M., Benitez-Silva, H., 2003. Dynamic structural models of retirement and disability. Mimeo. University of Maryland.
Rust, J., Phelan, C., 1997. How social security and medicare affect retirement behavior in a world of incomplete markets. Econometrica 65, 781–831.
Sickles, R., Taubman, P., 1986. An analysis of the health and retirement status of the elderly. Econometrica 54, 1339–1356.
Stock, J., Wise, D.A., 1990. Pensions, the option value of work, and retirement. Econometrica 58, 1151–1180.
Tartari, M., 2006. Indirect inference with panel data. Mimeo. Yale University.
Van der Klaauw, W., 1995. Female labor supply and marital status decisions: A life cycle model. Review of Economics Studies 63, 199–235.
Van der Klaauw, W., 2000. On the use of expectations data in estimating structural dynamic models: An analysis of career choices. Mimeo. UNC-Chapel Hill.
Van der Klaauw, W., Wolpin, K.I., 2005. Social Security and the Retirement and Savings Behavior of Low Income Households. PIER Working Paper No. 05-020.
Wolpin, K.I., 1984. An estimable dynamic stochastic model of fertility and child mortality. Journal of Political Economy 92, 852–875.
Wolpin, K.I, 1999. Commentary on analysis of choice expectations in incomplete scenarios by C.F. Manski. Journal of Risk and Uncertainty 19, 67–69.