How Taxes and Social Security Rules Affect Labor Supply Before and During Retirement *

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Abstract  

After estimating a detailed structural model of retirement, we simulate the effects on labor supply and public finances of three potential social security reforms: (1) Complete abolishment of the Social Security earnings test. (2) Removal of any taxation of Social Security benefits. (3) Making benefits a function of earnings in all years, rather than the highest 35 years of earnings. Preliminary estimates show that such reforms would likely trigger large labor supply responses.

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1 Introduction

The projected Social Security deficit constitutes a major source of concern for the sustainability of public expenditures. It comes as no surprise that the past decades have seen a constant and lively debate—among policymakers and academics alike—about potential ways to reduce this deficit. The scarcity of reliable quantitative projections of the impact of often-cited potential reforms might be surprising at first sight. However, the complexity of the incentive structure generated by social security rules and their interactions with the tax system limit the usefulness of “natural experiment”-type evaluations of reforms. More important, many policies that circulate in the debate have not been in place before, so that a structural model of labor supply behavior is indispensable to evaluate their effect.

In this paper, we augment the model described in French and Jones (2011) in order to account for more details of the tax and social security benefit system. We then simulate the model under a number of policy scenarios that have not received a lot of attention in the quantitative literature, but have been debated extensively in policy circles. One of the reasons for this is that they require a separation of the decisions of whether and how much to work on the one hand; and whether to claim social security benefits on the other hand. Many models assume that leaving the workforce and claiming benefits coincide and that both decisions are irreversible. In particular, we consider the following three policies in our analysis:

1. **Complete abolishment of the Social Security earnings test.** Until the year 2000, labor earnings of individuals aged 65–69 above a threshold of $15,500 led to withholding Social Security benefits at a marginal rate of 33%; future benefits were increased according to a complicated formula (Song and Manchester, 2007). We consider abolishing the earnings test for those age 62–64 as well.

2. **Removal of any taxation of Social Security benefits.** Since 1993, up to one half of Social Security benefits are subject to the Federal income tax at a marginal tax rate of 50% (85%) if a broad income measure exceeds $25,000 ($34,000) for single individuals and $32,000 ($44,000) for married filers (Page and Conway, 2010). Because individuals with higher earnings have more Social Security benefits taxed, this effectively creates a mechanism similar to the earnings tax, although its transfer feature is absent. The thresholds have not been adjusted for inflation since the introduction, so the feature has been affecting more and more individuals over time. Butrica, Smith, and Toder (2008) provide a full account of the reforms to the system that have taken place over the past decades.

3. **Making benefits a function of earnings in all years, rather than the highest 35 years of earnings.** Social Security benefits effectively depend
on a single state variable, Average Indexed Monthly Earnings (AIME), which is calculated from the 35 years in the labor force with highest earnings. For individuals who have not reached the maximum amount of AIME, this provision creates disincentive effects on the extensive margin after 35 years in the labor force because the benefit accrual rate drops sharply.\footnote{Goda, Shoven, and Slavov (2011) suggest several viable ways to abolish this discontinuity.} Goda, Shoven, and Slavov (2011) suggest several viable ways to abolish this discontinuity.

A common feature of all these policies is that their net budgetary impact depends on the magnitude of labor supply responses. If the consequences for the budget are estimated to be positive or (close to) neutral, there is likely to be widespread political support for such policies. For example, both the House of Representatives and the Senate approved the Senior Citizens Freedom to Work Act—abolishing the earnings tax for individuals aged 65-69 in the year 2000—by unanimous votes. This is in stark contrast to policies that involve clear “expansions” or “cuts” in the Social Security budget.

An important issue with all of the proposed reforms is that they potentially change incentives for “reverse retirement", which is prevalent in the data (Maestas, 2010) but is missing from many models that attempt to evaluate retirement policies (see Coile and Gruber (2007); Laitner and Silverman (2011), and all the papers in Gruber and Wise (2007)). Thus our model accounts for these incentives.

\section{The Model}

French and Jones (2011) describe the model we employ in all detail; we limit ourselves to characterizing the model’s main features and to highlighting the features we add in the simulations. The model seeks to explain the combined evolution of labor force participation, hours of work, social security benefit receipt, and savings for each age in the range 52-69. Individuals choose their consumption level, whether and how many hours to work, and when to apply for Social Security benefits. All predictions are derived from maximizing the expected value of

\begin{equation}
\sum_{t=52}^{94} S_{t-1} \beta^{t-52} \left( s_t \frac{1}{1-\nu} (C_t^{\gamma} L_t^{1-\gamma})^{1-\nu} + (1-s_t) \theta_B \frac{(A_t + \kappa)^{(1-\nu)\gamma}}{1-\nu} \right)
\end{equation}

to the constraints described below, where $C_t$ is consumption and $L_t$ is leisure in period $t$; $S_t$ ($s_t$) is the cumulative (single-period) probability to survive until age $t$.

\footnote{Liebman, Luttmer, and Seif (2009) investigate the effects of this discontinuity in work incentives as one of several such features created by the Social Security formulas. They find moderate effects on the labor supply elasticities at both the extensive and intensive margins, where the former appears to be more important for women and the latter for men. However, they are not able to isolate the effects of individual sources of discontinuities.}
with \( S_{51} = s_{52} = 1 \). Survival probabilities depend on age and health. If the individual dies, bequests of assets \( A_t \) are valued according to the function 
\[
\theta_B \left( \frac{(A_t + \kappa)^{(1-\nu)\gamma}}{1-\nu} \right).
\]

The preference parameters consist of the discount factor \( \beta \), the valuation of consumption relative to leisure \( \gamma \), the coefficient of relative risk aversion \( \nu \), and \( \theta_B \) and \( \kappa \) determining the valuation of bequests.

Preference heterogeneity is modelled as in Heckman and Singer (1986): We assume that individual tastes can be approximated by a discrete number of types; the parameter values and fractions of each type in the population are estimated from the model. We use attitudinal questions and past work history to help predict whether an individual is of a given type.

The key constraints of the model are as follows. First, the quantity of leisure is reduced by hours worked, per-period fixed cost of work, one-time fixed cost of re-entry into the labour force, and poor health. Second, the budget constraint implies that net asset accumulation equals the sum of labor income, social security benefits, private pensions, interest income, spousal income, and government transfers minus the sum of consumption and medical expenses. Individuals cannot finance consumption by borrowing against future income streams; government transfers provide a consumption floor (Hubbard, Skinner, and Zeldes, 1994). The distribution of medical expenses evolves according to an exogenous AR(1)-process; both its mean and its variance depend on age, health and the type of health insurance. The logarithm of wages is assumed to be a function of age, health status, and whether an individual is working full-time or part-time, plus a stochastic component that follows an AR(1) process.

Modelling private pensions is particularly important in our context because they provide a close substitute for Social Security. As in the case of medical care expenses, neglecting them could easily lead us to overstate the importance of Social Security’s features in explaining retirement. Pension benefits are a function of the worker’s age and past pension accruals. We assume that pension accruals are a function of a worker’s age, labor income, and health insurance type; we fit this function to confidential HRS pension data.

Several provisions of the Social Security System depend on individuals’ year of birth. We fit the model to a cohort born on average in 1933 and use the rules that apply for that birth year. A full account of the Social Security rules can be found in the “Green Book” (U.S. House of Representatives Committee on Ways and Means, 2004). Individuals receive no Social Security benefits until they apply; they can first apply for benefits at age 62. Upon applying the individual receives benefits until death. The individual’s Social Security benefits depend on his Average Indexed Monthly Earnings (\( AIME \)), which is roughly his average income during his 35 highest earnings years in the labor market. Apart from the incentives created by the age-dependence of the benefit schedule (which has been studied extensively), the
Social Security System provides three major incentives for (non-)participation in the labor force:

1. The Social Security Earnings Test taxes labor income of beneficiaries at a high rate. For individuals aged 62-64, each dollar of labor income above the “test” threshold of $9,120 leads to a 1/2 dollar decrease in Social Security benefits, until all benefits have been taxed away. For individuals aged 65-69 before 2000, each dollar of labor income above a threshold of $14,500 leads to a 1/3 dollar decrease in Social Security benefits, until all benefits have been taxed away. Although benefits taxed away by the earnings test are credited to future benefits, after age 64 the crediting rate is less than actuarially fair, so that the Social Security Earnings Test effectively taxes the labor income of beneficiaries aged 65-69.2 When combined with the aforementioned incentives to draw Social Security benefits by age 65, the Earnings Test discourages work after age 65. In 2000, the Social Security Earnings Test was abolished for those 65 and older. Because those born in 1933 (the average birth year in our sample) turned 67 in 2000, we assume that the earnings test was repealed at age 67 when we estimate the model. In our model, social security benefits enter the budget constraint net of the earnings tax and it is straightforward to turn this feature on and off in the simulations.

2. The taxation of up to one half of Social Security benefits for relatively high earners has complex labor supply implications. When the policy was first introduced in 1983, it constituted an unexpected reduction in benefits of roughly 20% for those with high non-labor income without changing their marginal tax rates. Page and Conway (2010) use a difference-in-difference approach to compare these individuals with a group whose non-labor income is so low that all benefits would be removed by the earnings tax before the taxation kicks in. They show that it increased their labor supply by 2-5%. These effects should be very different for forward-looking individuals who expect this policy to be in place; or for individuals whose marginal tax rates are affected. The model in French and Jones (2011) does not incorporate the taxation of Social Security benefits; we build it in using a mechanism similar to the earnings tax. We then re-estimate the model, tweaking this feature along similar lines as the earnings tax.

3. Using only 35 years with highest earnings for the calculation of AIME introduces disincentive effects for work once this number has been reached. While income earned by workers with less than 35 years of earnings automatically increases their AIME, income earned by workers with more than 35 years of

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2The credit rates are based on the benefit adjustment formula. If a year’s worth of benefits are taxed away between ages 62 and 64, benefits in the future are increased by 6.67%. If a year’s worth of benefits are taxed away between ages 65 and 66, benefits in the future are increased by 5.5%.
earnings increases their AIME only if it exceeds earnings in some previous year of work. Because Social Security benefits increase in AIME, this causes work incentives to drop after 35 years in the labor market. Modelling the accrual schedule precisely would require introducing the entire earnings history as an additional state variable, which is computationally infeasible. We instead follow French and Jones (2011) and approximate average accrual rates as a function of age, AIME, and current wages; we use estimated earnings history to compute the parameters of this function. We simulate the impact of two proposals to reform the accrual schedule, which were put forward by Goda, Shoven, and Slavov (2011): Using 40 years in the AIME computations instead of 35 and introducing a “paid up” category for Social Security once 40 years in the labor force have been reached, i.e. earnings would not be subject to the payroll tax and future benefits would not be affected. We incorporate these changes in the simulations by changing the parameters of our accrual function.

We numerically solve a recursive formulation of (1) subject to the budget constraints, the tax, Social Security, and pension rules, and the parameters of the exogenous processes for wages and medical expenses. We then simulate the model for a sample of 90,000 individuals drawn from the initial distribution of our sample and fit it to the data using the method of simulated moments. For each age in the range 52-69, we employ 21 moments on asset quantiles (1/3 and 2/3), job exit rates for each health insurance category, labor force participation conditional on the combination of asset quantile and health insurance status, labor force participation conditional on the preference index, and labor force participation and hours of work conditional health. We thus employ 378 moment conditions. Once we have used the estimation procedure to recover the “deep” parameters of the model, we can subsequently employ it to simulate a wide variety of policies.

3 Data

We estimate the model using data from the Health and Retirement Survey (HRS), a sample of non-institutionalized individuals aged 50 and older. In order to be able to work with a fairly stable set of institutional features, we use men born between 1931 and 1935 in the analysis. Since we aim to model behavior until age 69, we use the 8 bi-annual waves of data covering the period 1992-2006. Since our model is based on annual data, we need to impute some variables, although others are asked retrospectively for non-survey years.

Due to missing data and similar issues, we need to restrict the sample in several ways. First, we drop all individuals who spent over 5 years working for an employer who did not contribute to Social Security. These individuals usually work for state governments; we drop them because they often have low Social Security wealth and
large pension wealth. This is a type of heterogeneity our model is not well suited to handle. Second, we drop respondents with missing information on health insurance, labor force participation, hours, and assets. Table 1 summarizes the consequences of the various restrictions; we assume the lost observations are conditionally missing at random.

With the exception of assets and medical expenses, which are measured at the household level, our data are for male household heads. The HRS also asks respondents retrospective questions about their work history that allow us to infer whether the individual worked in non-survey years. The procedures we use to impute the other variables are described in Online Appendix G of French and Jones (2011). The parameters of the (exogenous) wage and medical care processes are estimated outside the model using the procedures described in French (2005) and French and Jones (2004), respectively.

### 4 Preliminary Results

Since re-estimation of the model takes several weeks, we do not have the results on the precise reforms at this point. However, we can point out some experiments with the model used in French and Jones (2011), which were only partly reported in that paper. The results show that the impact of changes similar to the ones we analyze in this paper are sizable. Both of these are primarily concerned with the earnings tax.

Table 2 contains the results of a hold-out experiment conducted to validate the model used in French and Jones (2011). In particular, it contains the labor force participation rates for the 1933 and 1939 cohorts as found in the data and as predicted by the model. All model parameters are based on the earlier cohort; but the simulations use the initial conditions and Social Security Rules in effect for each of the cohorts separately. The most important rule change is that the earnings test after age 64 was repealed for the earlier cohort only at age 67; the younger cohort was never affected by it. The table shows that the model is able to track the data.
Table 2: Participation Rates by Birth Year Cohort, Table VI in French and Jones (2011)

<table>
<thead>
<tr>
<th>Age</th>
<th>Data 1933 (1)</th>
<th>Data 1939 (2)</th>
<th>Difference $^\dagger$ (3)</th>
<th>Model 1933 (4)</th>
<th>Model 1939 (5)</th>
<th>Difference $^\ast$ (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.657</td>
<td>0.692</td>
<td>0.035</td>
<td>0.650</td>
<td>0.706</td>
<td>0.056</td>
</tr>
<tr>
<td>61</td>
<td>0.636</td>
<td>0.642</td>
<td>0.006</td>
<td>0.622</td>
<td>0.677</td>
<td>0.055</td>
</tr>
<tr>
<td>62</td>
<td>0.530</td>
<td>0.545</td>
<td>0.014</td>
<td>0.513</td>
<td>0.570</td>
<td>0.057</td>
</tr>
<tr>
<td>63</td>
<td>0.467</td>
<td>0.508</td>
<td>0.041</td>
<td>0.456</td>
<td>0.490</td>
<td>0.035</td>
</tr>
<tr>
<td>64</td>
<td>0.408</td>
<td>0.471</td>
<td>0.063</td>
<td>0.413</td>
<td>0.449</td>
<td>0.037</td>
</tr>
<tr>
<td>65</td>
<td>0.358</td>
<td>0.424</td>
<td>0.066</td>
<td>0.378</td>
<td>0.459</td>
<td>0.082</td>
</tr>
<tr>
<td>66</td>
<td>0.326</td>
<td>0.382</td>
<td>0.057</td>
<td>0.350</td>
<td>0.430</td>
<td>0.080</td>
</tr>
<tr>
<td>67</td>
<td>0.314</td>
<td>0.374</td>
<td>0.060</td>
<td>0.339</td>
<td>0.386</td>
<td>0.047</td>
</tr>
<tr>
<td>Total, 60-67</td>
<td>3.696</td>
<td>4.037</td>
<td>0.341</td>
<td>3.721</td>
<td>4.168</td>
<td>0.447</td>
</tr>
</tbody>
</table>

$^\dagger$ Column (2) − Column (1). $^\ast$ Column (5) − Column (4).

quite well out of sample. Labor force participation rates increased quite strongly and the experiments in French and Jones (2011) suggest that a large share of this increase is due to the abolishment of the income tax starting at age 65.

As a second experiment, we consider changing the parameters of the earnings test so that its rules at ages 62-64 are carried forward to ages 65-66; it continues to be repealed at age 67. All simulations are for the 1933 cohort. Column (2) of Table 3 shows labor supply predicted by the model. To test the sensitivity of labor supply to the earnings test, we set the exemption level and clawback rate for ages 65-66 to their values at ages 62-64. Column (3) shows that even such a modest change causes labor force participation over ages 60-69 to drop 1.6 percentage points per year.

Based on these and other results with the model in French and Jones (2011) as well as some prior experimentation with the taxation of Social Security benefits, we expect the policy changes we are analysing in this paper to have non-negligible impact. They could provide viable strategies to increase labor supply around retirement without severely affecting the Federal Budget.

$^3$Recall that during ages 62-64 the earnings test exemption level is lower, and the clawback rate is higher, than during ages 65-66.
<table>
<thead>
<tr>
<th>Age</th>
<th>Baseline Data (1)</th>
<th>Baseline Model (2)</th>
<th>Modified Earnings Test† (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0.657</td>
<td>0.650</td>
<td>0.650</td>
</tr>
<tr>
<td>61</td>
<td>0.636</td>
<td>0.622</td>
<td>0.622</td>
</tr>
<tr>
<td>62</td>
<td>0.530</td>
<td>0.513</td>
<td>0.513</td>
</tr>
<tr>
<td>63</td>
<td>0.467</td>
<td>0.456</td>
<td>0.456</td>
</tr>
<tr>
<td>64</td>
<td>0.407</td>
<td>0.413</td>
<td>0.402</td>
</tr>
<tr>
<td>65</td>
<td>0.358</td>
<td>0.378</td>
<td>0.307</td>
</tr>
<tr>
<td>66</td>
<td>0.326</td>
<td>0.350</td>
<td>0.285</td>
</tr>
<tr>
<td>67</td>
<td>0.314</td>
<td>0.339</td>
<td>0.328</td>
</tr>
<tr>
<td>68</td>
<td>0.304</td>
<td>0.307</td>
<td>0.306</td>
</tr>
<tr>
<td>69</td>
<td>0.283</td>
<td>0.264</td>
<td>0.266</td>
</tr>
<tr>
<td>Total 60-69</td>
<td>4.283</td>
<td>4.292</td>
<td>4.137</td>
</tr>
</tbody>
</table>

† Earnings test clawback rate and threshold for ages 65-66 set to age-62-64 values.
References


Maestas, Nicole (Summer 2010). “Back to Work: Expectations and Realizations of Work after Retirement”. In: Journal of Human Resources 45.3, pp. 718–748.

A Detailed Model Description

A.1 Preferences and Demographics

Household heads seek to maximize their expected discounted (where the subjective discount factor is \( \beta \)) lifetime utility at age \( t \), \( t = 52, 53, \ldots, 95 \). Each period that he lives, the individual derives utility from consumption, \( C_t \), and hours of leisure, \( L_t \). The within-period utility function is of the form:

\[
U(C_t, L_t) = \frac{1}{1 - \nu} (C_t^{\gamma} L_t^{1-\gamma})^{1-\nu}.
\]

We allow both \( \beta \) and \( \gamma \) to vary across individuals. Individuals with higher values of \( \beta \) are more patient, while individuals with higher values of \( \gamma \) place less weight on leisure.

The quantity of leisure is:

\[
L_t = L - N_t - \phi_P tP_t - \phi_{RE} tRE_t - \phi_H H_t,
\]

where \( L \) is the individual’s total annual time endowment. Participation in the labor force is denoted by \( P_t \), a 0-1 indicator equal to one when hours worked, \( N_t \), are positive. The fixed cost of work, \( \phi_P t \), is treated as a loss of leisure. Workers that leave the labor force can re-enter; re-entry is denoted by the 0-1 indicator \( RE_t = 1\{P_t = 1 \text{ and } P_{t-1} = 0\} \), and individuals re-entering the labor market incur the cost \( \phi_{RE} \). The quantity of leisure also depends on an individual’s health status through the 0-1 indicator \( H_t = 1\{health_t = \text{bad}\} \), which equals one when his health is bad.

Workers alive at age \( t \) survive to age \( t+1 \) with probability \( s_{t+1} \). Workers that die value bequests of assets, \( A_t \), according to the function \( b(A_t) \):

\[
b(A_t) = \theta_B \frac{(A_t + \kappa)^{1-\nu\gamma}}{1 - \nu}.
\]

The survival probability \( s_t \), along with the transition probabilities for the health variable \( H_t \), depend on age and previous health status.
A.2 Budget Constraints

The individual holds three forms of wealth: assets (including housing); pensions; and Social Security. He has several sources of income: asset income, $rA_t$, where $r$ denotes the constant pre-tax interest rate; labor income, $W_tN_t$, where $W_t$ denotes wages; spousal income, $ys_t$; pension benefits, $pb_t$; Social Security benefits, $ss_t$; and government transfers, $tr_t$. The asset accumulation equation is:

$A_{t+1} = A_t + Y_t + ss_t + tr_t - M_t - C_t$.

$M_t$ denotes medical expenses. Post-tax income, $Y_t = Y(rA_t + W_tN_t + ys_t + pb_t, \tau)$, is a function of taxable income and the vector $\tau$, described in Appendix ??, that captures the tax structure.

Individuals face the borrowing constraint:\footnote{We assume that $tr_t$ medical expenses are realized after time-$t$ labor decisions have been made. We view this as preferable to the alternative assumption that the time-$t$ medical expense shocks are fully known when workers decide whether to hold on to their employer-provided health insurance. Given the borrowing constraint and timing of medical expenses, an individual with extremely high medical expenses this year could have negative net worth next year. Because many people in our data have unresolved medical expenses, medical expense debt seems reasonable.}

$$A_t + Y_t + ss_t + tr_t - C_t \geq 0.$$  

Following Hubbard, Skinner, and Zeldes (1994, 1995), Government transfers provide a consumption floor:

$$tr_t = \max\{0, C_{min} - (A_t + Y_t + ss_t)\}.$$  

Equation (7) implies that government transfers bridge the gap between an individual's "liquid resources" (the quantity in the inner parentheses) and the consumption floor. Treating $C_{min}$ as a sustenance level, we further require that $C_t \geq C_{min}$. Our treatment of government transfers implies that individuals will always consume at least $C_{min}$, even if their out-of-pocket medical expenses exceed their financial resources.

A.3 Medical Expenses, Health Insurance, and Medicare

We define $M_t$ as the sum of all out-of-pocket medical expenses, including insurance premia and expenses covered by the consumption floor. We assume that an individual’s medical expenses depend upon five components. First, medical expenses depend on the individual’s employer-provided health insurance, $I_t$. Second, they depend on whether the person is working, $P_t$, because workers who leave their job often pay a larger fraction of their insurance premiums. Third, they depend on the individual’s self-reported health status, $H_t$. Fourth, medical expenses depend on age. At age 65,
individuals become eligible for Medicare, which is a close substitute for employer-provided coverage. Offsetting this, as people age their health declines (in a way not captured by $H_t$), raising medical expenses. Finally, medical expenses depend on the person-specific component $\psi_t$, yielding:

\[
\ln M_t = m(H_t, I_t, t, P_t) + \sigma(H_t, I_t, t, P_t) \cdot \psi_t.
\]

Note that health insurance affects both the expectation of medical expenses, through $m(.)$ and the variance, through $\sigma(.)$

Even after controlling for health status, French and Jones (2004) find that medical expenses are very volatile and persistent. Thus we model the person-specific component of medical expenses, $\psi_t$, as:

\[
\psi_t = \zeta_t + \xi_t, \quad \xi_t \sim \mathcal{N}(0, \sigma^2_\xi),
\]

\[
\zeta_t = \rho m \zeta_{t-1} + \varepsilon_t, \quad \varepsilon_t \sim \mathcal{N}(0, \sigma^2_\varepsilon),
\]

where $\xi_t$ and $\varepsilon_t$ are serially and mutually independent. $\xi_t$ is the transitory component, while $\zeta_t$ is the persistent component, with autocorrelation $\rho_m$.

We assume that there are three mutually exclusive categories of health insurance coverage. The first is “retiree” coverage, where workers keep their health insurance even after leaving their jobs. The second category is “tied” health insurance, where workers receive employer-provided coverage as long as they continue to work. If a worker with “tied” health insurance leaves his job, he can keep his health insurance coverage for that year. This is meant to proxy for the fact that most firms must provide “COBRA” health insurance to workers after they leave their job. After one year of “tied” coverage and not working, the individual’s insurance ceases. The third category consists of individuals whose potential employers provide no health insurance at all, or “none”. Workers move between these insurance categories according to:

\[
I_t = \begin{cases} 
\text{retiree} & \text{if } I_{t-1} = \text{retiree} \\
\text{tied} & \text{if } I_{t-1} = \text{tied} \land N_{t-1} > 0 \\
\text{none} & \text{if } I_{t-1} = \text{none} \lor I_{t-1} = \text{tied} \land N_{t-1} = 0
\end{cases}
\]

**A.4 Wages and Spousal Income**

We assume that the logarithm of wages at time $t$, $\ln W_t$, is a function of health status ($H_t$), age ($t$), hours worked ($N_t$) and an autoregressive component, $\omega_t$:

\[
\ln W_t = W(H_t, t) + \alpha \ln N_t + \omega_t.
\]

The inclusion of hours, $N_t$, in the wage determination equation captures the empirical regularity that, all else equal, part-time workers earn relatively lower
wages than full time workers. The autoregressive component $\omega_t$ has the correlation coefficient $\rho_W$ and the normally-distributed innovation $\eta_t$:

$$\omega_t = \rho_W \omega_{t-1} + \eta_t, \quad \eta_t \sim \mathcal{N}(0, \sigma^2_\eta).$$

Because spousal income can serve as insurance against medical shocks, we include it in the model. In the interest of computational simplicity, we assume that spousal income is a deterministic function of an individual’s age and health status:

$$y_{st} = y_s(H_t, t).$$

### A.5 Social Security and Pensions

Because pensions and Social Security generate potentially important retirement incentives, we model the two programs in detail.

Individuals receive no Social Security benefits until they apply. Individuals can first apply for benefits at age 62. Upon applying the individual receives benefits until death. The individual’s Social Security benefits depend on his Average Indexed Monthly Earnings ($AIME$), which is roughly his average income during his 35 highest earnings years in the labor market.

The Social Security System provides three major retirement incentives. First, while income earned by workers with less than 35 years of earnings automatically increases their $AIME$, income earned by workers with more than 35 years of earnings increases their $AIME$ only if it exceeds earnings in some previous year of work. Because Social Security benefits increase in $AIME$, this causes work incentives to drop after 35 years in the labor market. We describe the computation of $AIME$ in more detail below.

Second, the age at which the individual applies for Social Security affects the level of benefits. For every year before age 65 the individual applies for benefits, benefits are reduced by 6.67% of the age-65 level. This is roughly actuarially fair. But for every year after age 65 that benefit application is delayed, benefits rise by 5.5% up until age 70. This is less than actuarially fair, and encourages people to apply for benefits by age 65.

Third, the Social Security Earnings Test taxes labor income of beneficiaries at a high rate. For individuals aged 62-64, each dollar of labor income above the “test” threshold of $9,120 leads to a 1/2 dollar decrease in Social Security benefits, until all benefits have been taxed away. For individuals aged 65-69 before 2000, each

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5A description of the Social Security rules can be found in U.S. House of Representatives Committee on Ways and Means (2004). Some of the rules, such as the benefit adjustment formula, depend on an individual’s year of birth. Because we fit our model to a group of individuals that on average were born in 1933, we use the benefit formula for that birth year.
A dollar of labor income above a threshold of $14,500 leads to a 1/3 dollar decrease in Social Security benefits, until all benefits have been taxed away. Although benefits taxed away by the earnings test are credited to future benefits, after age 64 the crediting rate is less than actuarially fair, so that the Social Security Earnings Test effectively taxes the labor income of beneficiaries aged 65-69. When combined with the aforementioned incentives to draw Social Security benefits by age 65, the Earnings Test discourages work after age 65. In 2000, the Social Security Earnings Test was abolished for those 65 and older. Because those born in 1933 (the average birth year in our sample) turned 67 in 2000, we assume that the earnings test was repealed at age 67. These incentives are incorporated in the calculation of \( ss_t \), which is defined to be net of the earnings test.

Pension benefits, \( pb_t \), are a function of the worker’s age and pension wealth. Pension wealth (the present value of pension benefits) in turn depends on pension accruals. We assume that pension accruals are a function of a worker’s age, labor income, and health insurance type, using a formula estimated from confidential HRS pension data. The data show that pension accrual rates differ greatly across health insurance categories; accounting for these differences is essential in isolating the effects of employer-provided health insurance. When finding an individual’s decision rules, we assume further that the individual’s existing pension wealth is a function of his Social Security wealth, age, and health insurance type. Details of our pension model are described in the online appendix to French and Jones (2011).

A.6 Computation of AIME

We model several key aspects of Social Security benefits. First, Social Security benefits are based on the individual’s 35 highest earnings years, relative to average wages in the economy during those years. The average earnings over these 35 highest earnings years are called Average Indexed Monthly Earnings, or AIME. It immediately follows that working an additional year increases the AIME of an individual with less than 35 years of work. If an individual has already worked 35 years, he can still increase his AIME by working an additional year, but only if his current earnings are higher than the lowest earnings embedded in his current AIME. To account for real wage growth, earnings in earlier years are inflated by the growth rate of average earnings in the overall economy. For the period 1992-1999, average real wage growth, \( g \), was 0.016 U.S. House of Representatives Committee on Ways and Means (2004). This indexing stops at the year the worker turns 60, however, and earnings accrued after age 60 are not rescaled. Furthermore, AIME is capped. In 1998, the base year for

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6 The credit rates are based on the benefit adjustment formula. If a year’s worth of benefits are taxed away between ages 62 and 64, benefits in the future are increased by 6.67%. If a year’s worth of benefits are taxed away between ages 65 and 66, benefits in the future are increased by 5.5%.

7 After age 62, nominal benefits increase at the rate of inflation.
the analysis, the maximum AIME level was $68,400.

Precisely modelling these mechanics would require us to keep track of a worker’s entire earnings history, which is computationally infeasible. As an approximation, we assume that (for workers beneath the maximum) annualized AIME is given by:

$$AIME_{t+1} = (1 + g \cdot 1\{t \leq 60\}) AIME_t + \frac{1}{35} \max\{0, W_t N_t - \alpha_t (1 + g \cdot 1\{t \leq 60\}) AIME_t\},$$

where the parameter $\alpha_t$ approximates the ratio of the lowest earnings year to AIME. We assume that 20% of the workers enter the labor force each year between ages 21 and 25, so that $\alpha_t = 0$ for workers aged 55 and younger. For workers aged 60 and older, earnings update AIME only if current earnings replace the lowest year of earnings, so we estimate $\alpha_t$ by simulating wage (not earnings) histories with the model developed in French (2005), calculating the sequence \(1\{\text{time-t earnings do not increase AIME}_t\}\}_{t \geq 60}$ for each simulated wage history, and estimating $\alpha_t$ as the average of this indicator at each age. Linear interpolation yields $\alpha_{56}$ through $\alpha_{59}$.

AIME is converted into a Primary Insurance Amount (PIA) using the formula:

$$PIA_t = \begin{cases} 0.9 \cdot AIME_t & \text{if } AIME_t < $5,724 \\ $5,151.6 + 0.32 \cdot (AIME_t - 5,724) & \text{if } $5,724 \leq AIME_t < $34,500 \\ $14,359.9 + 0.15 \cdot (AIME_t - 34,500) & \text{if } AIME_t \geq $34,500 \end{cases}.$$

Social Security benefits $ss_t$ depend both upon the age at which the individual first receives Social Security benefits and the Primary Insurance Amount. For example, pre-Earnings Test benefits for a Social Security beneficiary will be equal to PIA if the individual first receives benefits at age 65. For every year before age 65 the individual first draws benefits, benefits are reduced by 6.67% and for every year (up until age 70) that benefit receipt is delayed, benefits increase by 5.0%. The effects of early or late application can be modelled as changes in AIME rather than changes in PIA, eliminating the need to include age at application as a state variable. For example, if an individual begins drawing benefits at age 62, his adjusted AIME must result in a PIA that is only 80% of the PIA he would have received had he first drawn benefits at age 65. Using equation (16), this is easy to find.

A.7 Recursive Formulation

In addition to choosing hours and consumption, eligible individuals decide whether to apply for Social Security benefits; let the indicator variable $B_t \in \{0, 1\}$ equal one if an individual has applied. In recursive form, the individual’s problem can be written
as

\[ V_t(X_t) = \max_{C_t,N_t,B_t} \left\{ \frac{1}{1-\nu} \left( C_t^\gamma (L - N_t - \phi_P P_t - \phi_{RE} RE_t - \phi_H H_t)^{1-\gamma} \right)^{1-\nu} \right. \]

\[ + \beta (1 - s_{t+1}) b(A_{t+1}) \]

\[ + \beta s_{t+1} \int V_{t+1}(X_{t+1}) dF(X_{t+1}|X_t,t,C_t,N_t,B_t) \right\}, \]

subject to equations (6) and (7). The vector \( X_t = (A_t, B_{t-1}, H_t, \text{AIM} E_t, I_t, P_{t-1}, \omega_t, \zeta_{t-1}) \) contains the individual’s state variables, while the function \( F(\cdot|\cdot) \) gives the conditional distribution of these state variables, using equations (5) and (8) - (14). The solution to the individual’s problem consists of the consumption rules, work rules, and benefit application rules that solve equation (17). These decision rules are found numerically using value function iteration. French and Jones (2011) describes our numerical methodology in more detail.