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THE ROLE OF RETIREE HEALTH INSURANCE IN THE EMPLOYMENT BEHAVIOR OF OLDER MEN*

BY DAVID M. BLAU AND DONNA B. GILLESKIE[1]

Ohio State University, U.S.A; University of North Carolina at Chapel Hill and NBER, U.S.A

Using data from the Health and Retirement Survey, we estimate preference and expectations parameters of a structural model of the employment and medical care decisions of older men in order to evaluate the role of health insurance. The budget constraint incorporates detailed cost-sharing characteristics of private health insurance and Medicare as well as rules and requirements associated with Social Security and private pensions. Simulations imply that changes in health insurance, including access and restrictions to retiree health insurance and Medicare, have a modest impact on employment behavior among older males, with the greatest effect on men in bad health.

1. INTRODUCTION

A large majority of adults in the United States who have health insurance are covered by plans provided by employers until they become eligible for Medicare at age 65. Some employers extend health insurance coverage to retirees, whereas others terminate coverage when an individual leaves the firm. A risk-averse individual who believes there is some chance that he will incur large medical expenses is likely to place a high value on health insurance. If such an individual faces loss of his employer-provided health insurance by retiring, then he has an incentive to remain with his employer longer than he would if health insurance was not linked to his employment status.[2]

Recent proposals for reform of the U.S. health insurance system would fully or partly break the close link between health insurance coverage and employment for older individuals. For example, the Clinton Administration proposed a reform that would allow individuals to purchase Medicare beginning at age 62 years. The Health Insurance Portability and Accountability Act of 1996 forbids

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[2] Alternatively, individuals who would lose their health insurance upon retiring could purchase an individual health insurance policy. Such policies, however, are generally not a good substitute for employer-provided (group) health insurance because they have much higher premiums for a given level of coverage than employer-provided policies and they often exclude coverage for pre-existing conditions (Simantov et al., 2001).

insurance companies from denying coverage to individuals aged 55–64 who apply for health insurance after losing employer-provided coverage. More recently, the Bush Administration promoted the use of tax-free health savings accounts and suggested that premiums be tax deductible for those with such accounts. The state of Massachusetts passed a bill requiring all uninsured residents in the state to purchase some kind of insurance policy by July 1, 2007, or face a fine. If the availability of health insurance coverage influences the employment decisions of older individuals, then such reforms could encourage early exit from the labor force. Recent and proposed new Social Security reforms have been designed to encourage later retirement, but if health insurance reform has the opposite effect there could be serious consequences for the already uncertain financial prospects of both Social Security and Medicare, which are financed through payroll taxes.

The possibility that health insurance influences retirement behavior has attracted considerable attention from researchers in the last few years. Evidence from recent studies suggests that the availability of retiree health insurance has a strong impact on the employment behavior of older men. Much of the evidence is derived from reduced form models or models that represent approximations to the employment decision rules implied by economic theory. For example, in earlier work we found that the annual labor force exit rate of men aged 61 whose employer-provided health insurance includes retiree coverage is 7.5 percentage points higher than the rate for men whose employer-provided insurance does not include retiree coverage.[3] Evidence of this type is useful in establishing the existence of an effect but cannot necessarily be used to evaluate the impact of proposed policy reforms. The provisions of employer-provided health insurance, such as the premium, deductible, coinsurance rate, and so forth, vary widely across plans. The impact of retiree coverage estimated in reduced form and approximation studies is an average of the impact of plans with different provisions. In our earlier paper we show that the effect of retiree coverage is much larger if the employer pays the entire premium than if the worker and employer share the cost of the premium. The effect of a reform that mandated extension of employer-provided retiree coverage to all workers might be well approximated by estimates from reduced form and approximation models. However, even in this case, the Lucas critique applies: The effect of health insurance on employment behavior might change as the structure of health insurance changes because demand for medical care will change as financial constraints are altered. And the effect of reforms such as extending Medicare coverage to individuals aged 62–64 and requiring insurers to provide coverage to older individuals who lose employer-provided coverage could not be reliably estimated from reduced form or approximation models because Medicare and private health insurance characteristics differ significantly from the provisions of typical existing employer plans.

Structural models of labor force exit decisions that incorporate health insurance provide a basis for policy evaluation if the models incorporate health insurance

[3] Blau and Gilleskie (2001a). See Gruber and Madrian (1995, 1996), Karoly and Rogowski (1994), and Madrian (1994) for related evidence.

in a realistic way. In order to determine whether the spike in retirement at age 65 can be explained by incomplete health insurance prior to age 65 (i.e., Medicare is available to all individuals 65 and older regardless of employment), Gustman and Steinmeier (1994) and Lumsdaine et al. (1994) evaluate the role of retiree coverage by adding the *average* employer health care cost to the budget constraint (effectively increasing the value of the compensation package). They find that parameter estimates and implied retirement behavior are virtually identical with or without this health insurance component. Rust and Phelan (1997) point out that health insurance is likely to be valued by risk-averse individuals for the coverage it provides against catastrophic medical bills caused by low-probability major adverse health shocks. Estimates obtained by valuing insurance at its average cost do not account for the role of insurance in smoothing consumption across uncertain health states. The retirement model of Rust and Phelan allows for risk aversion and incorporates the entire distribution of medical expenditures, conditional on health insurance, instead of the mean only. Their estimates indicate that individuals in their Retirement History Survey (RHS) sample from the 1970s are quite risk averse and that the availability of retiree coverage has a substantial impact on the timing of labor force exit.

In this article, we specify a dynamic structural model of employment and medical care decisions and estimate its parameters using data on men aged 50–67 from the Health and Retirement Study (HRS) spanning the 1990s. The analysis has two unique features that distinguish it from the approaches followed by previous studies. First, the model allows individuals to choose the amount of medical care to consume. Previous models have treated medical expenditure as an exogenous stochastic process. This would be a good approach if medical care is determined entirely by health status and the decisions of medical professionals. But if individuals are willing and able to substitute between medical care and other consumption in response to health shocks, then assuming that medical expenditure is exogenous could yield misleading inferences.[4]

Second, we supplement the HRS survey responses with information from employers and Social Security records that allows us to measure the budget constraints facing the individuals in our sample more accurately than in previous studies. Accurate measurement of budget constraint components is crucial for producing believable estimates from a structural model, and is difficult as a result of both the complexity of the within-period constraint and the fact that an individual's decisions in one period affect his budget set in subsequent periods. Data from Social Security earnings records along with information provided by employers on their health insurance and pension provisions allow us to model these dynamics with much greater accuracy than is possible with individual survey responses alone. Previous studies of this issue have not had access to data of this type and have been forced to rely on crude approximations to the budget set. We use our data to accurately model the impact of each employment choice on current and future health insurance coverage and Social Security and pension

[4] Evidence from studies of the demand for medical care shows price elasticity estimates in the range from −0.14 to −0.43 (Newhouse, 1993).

benefits. Furthermore, we account for the substantial variation across the sample in health insurance plan characteristics such as premium, deductible, coinsurance, and maximum coverage. This variation is another important motivation for modeling medical care decisions instead of treating medical expenditures as given or randomly drawn from a distribution. Out-of-pocket medical expenditure is the outcome of medical care consumption decisions interacted with the cost-sharing parameters of health insurance coverage. Using data on the price and quantity of medical care together with health insurance plan characteristics makes it possible to determine whether health insurance plan characteristics influence medical care demand. This approach also allows us to evaluate the impact of alternative insurance plans with different cost-sharing characteristics.

Our modeling approach is thus a significant advance over previous studies, but it does have some limitations. First, like previous studies we treat health insurance coverage as given.[5] A model in which health insurance is a choice could not be estimated because the state space and choice set become unmanageable. Additionally, attempts to account for the uncertain availability of particular insurance options requires many assumptions regarding, for example, spouse employment, the spouse's insurance offers, discontinuation of coverage by a firm, etc.[6] Thus, if an older individual can easily obtain from another source health insurance coverage comparable to coverage from his employer, our model would be misspecified. This seems unlikely because of high premiums for private plans and exclusion of pre-existing conditions (pre-HIPAA).[7] We also do not model COBRA coverage.[8]

[5] We do, however, account for the loss of coverage as a result of leaving a job that provides health insurance without retiree coverage. What we do not account for is the possibility of gaining coverage from a new firm or by purchasing private nongroup coverage, or losing coverage as a result of the firm terminating a plan.

[6] Dey and Flinn (2005) model the choice of health insurance and employment in a continuous time, stationary search framework where health insurance, a one-dimensional characteristic of job offers, influences current period utility through preferences and has the future benefit of reducing the risk of a current job separation (induced by an exogenous health shock). Khwaja (2006) expands the set of endogenous health insurance alternatives in a model of life-cycle health determination, but assumes that each (non-Medicare) insurance option is available to all individuals.

[7] The Health Insurance Portability and Accountability Act (HIPAA) of 1996 increased health insurance accessibility to individuals changing jobs. The ability of employers to deny coverage because of pre-existing conditions has been limited but has not been eliminated. More specifically, the interim rules state that for all plan years starting after June 30, 1997, employers and health insurers may impose a pre-existing condition exclusion only if: the exclusion relates to a condition for which the beneficiary received medical advice, diagnosis or treatment within the last 6 months; the exclusion lasts for no more than 12 months after the enrollment date; and the length of the exclusion is also reduced by the period of time for which the beneficiary had health insurance prior to the enrollment date. We do not model this possibility due to its dependence on information we do not observe and because our data span the years 1992–98. (The final rules, which are substantially the same but include some clarifications, became effective for plan years beginning after June 30, 2005.)

[8] The Consolidated Omnibus Budget Reconciliation Act of 1985 (COBRA) requires firms that provide health insurance to offer coverage to employees (and their dependents) who leave the firm, for up to 18 (36) months after they leave, at a premium to the ex-employee of no more than 102% of the cost of the coverage. In principle, this provides a bridge to Medicare for individuals who leave employment at around age 63. However, Gruber and Madrian (1995, 1996) find that whereas the COBRA and earlier state continuation-of-coverage mandates seem to have induced an increase in

Second, we do not model savings behavior, again for computational reasons.[9] An individual who expects to lose health insurance coverage upon leaving his employer could save in anticipation of this event, thus self-insuring against health risk. Models of retirement that account for savings behavior find that income losses, associated with Social Security benefit reductions for example, modestly impact savings accumulation (van der Klaauw and Wolpin, 2005). This suggests that we may overstate the effect of retiree health insurance coverage if avenues of income smoothing are not modeled. However, evidence on saving and health insurance shows that individuals who are uninsured have much lower wealth, other things equal, than individuals with health insurance (Starr-McCluer, 1996). In fact, uninsured individuals have on average essentially no financial wealth. This evidence does not rule out the existence of precautionary saving behavior, but it does suggest that its impact is likely to be minimal.

Finally, we do not model the joint employment and medical care decisions of married couples. This could be important if health insurance from one spouse's employer covers both spouses, and the spouse with coverage therefore faces employment incentives to maintain coverage for both spouses. In this article, we allow for health insurance coverage from the wife, but we do not model the wife's employment or medical care decisions. Elsewhere, we analyze the joint employment behavior of married couples but treat individual medical care expenditures as exogenous (Blau and Gilleskie, 2006).

Our estimated model predicts the observed employment behavior of the sample quite well. Our model also fits health transitions and the number of doctor visits well, but overpredicts hospital nights. Using the estimated structural parameters, we re-solve the individual's optimization problem under different insurance policy scenarios and compare employment behavior. We simulate the impact of the availability of retiree health insurance for all individuals with employer-provided insurance and compare this to behavior when retiree insurance is unavailable. If health insurance is highly valued, then we should observe changes in employment choices when the link between health insurance and employment is altered. We find that the nonemployment rate is 4.7 percentage points lower when retiree health insurance is eliminated: a 15% effect (among those who previously held employer-provided coverage with retiree benefits). The nonemployment rate of men who previously had employer-provided health insurance with no retiree coverage rises 3.6 percentage points when retiree health benefits are added to the plans (a 50% effect). Conditional on previous employment, changes in nonemployment rates are smaller: about one percentage point (in the expected direction for each affected group) or a 13% effect. Individuals in poor health, however, experience changes in nonemployment hazards of around three percentage points: those previously employed who lose EPRHI are almost 20% less likely to be

the labor force exit rate among older men, the effect is no larger at ages 63 and 64 than at younger ages, and in one of their data sets the effects are much stronger at younger ages. Unfortunately for purposes of modeling such coverage, the HRS data set only provides insurance information at each wave (every two years) and does not specifically identify COBRA coverage.

[9] Savings is a decision variable in the labor supply (e.g., retirement and job search) models of French (2005), French and Jones (2004), Rendon (2006), and van der Klaauw and Wolpin (2005).

nonemployed whereas those who gain EPRHI are 30% more likely to be nonemployed one year later. Those in good health alter their behavior by less than 10%. Our results suggest that employer-provided retiree health insurance has a modest effect on employment decisions of older men in general, but a much larger impact on men in poor health. We conclude that retiree health insurance facilitates early retirement for men in poor health, and plays only a small role in the retirement decisions of men in good health.

In the next section we specify the optimization problem. Section 3 discusses the data and Section 4 presents results and policy simulations. Section 5 concludes.

2. THE MODEL

We specify a dynamic stochastic model of employment and medical care decisions of older men. We present the basic elements of the model here, omitting some details in order to clearly spell out the key ideas of our approach. The details are fairly complex as a result of both the richness and the limitations of our data, and the complexity of Social Security, pension, and health insurance benefits. Additional details are provided in the Appendix, and Section 3 below describes features of the data that influence some of the modeling decisions.

We specify a discrete-state, discrete-time model with a finite horizon, T^*, which is the maximum age to which any individual can survive. The length of a period in the model is one year. There is no capital market, so consumption equals income each period. The three decision variables each period are employment and two types of medical care consumption: doctor visits and hospital nights. The state variables that are determined by the individual's choices (and by realizations of stochastic processes) are employment status, health status, and cumulative years of work experience. Medical care choices affect contemporaneous utility directly through the utility function and indirectly through the budget constraint. There is also a dynamic productive component to medical care, as it impacts health transition probabilities from one period to the next. The employment decision has future consequences because earnings, pension benefits, Social Security benefits, and health insurance coverage may depend on employment status and experience at the beginning of each period.

Individuals face three sources of uncertainty about the future: health, layoffs, and preferences. Realizations of the stochastic processes that determine the period-t values of these variables occur at the beginning of the period. These realizations, together with the choices made by the individual in the past, determine his choice set for the current period. He makes his employment and medical care choices from the available choice set each period, and these decisions are then fixed for the duration of the period. In addition to observed choices and stochastic outcomes, observed characteristics (such as age, education, race, and marital status) differentiate individuals. Permanent unobserved differences among individuals also influence behavior.

2.1. *Per-period Alternatives.*

The employment states in period t are employed ($e_t = 1$) and not employed ($e_t = 0$). Individuals who were previously employed

($e_{t-1} = 1$) face a lay off probability ϕ at the beginning of each period. The employment alternatives available to an individual who was previously employed ($e_{t-1} = 1$) and is not laid off ($f_t = 0$) are: leave the labor force ($j = 1$), take a new job ($j = 2$), or stay on the same job ($j = 3$). Individuals who were previously not employed ($e_{t-1} = 0$) or who were employed and are laid off ($e_{t-1} = 1$ and $f_t = 1$) have two alternatives: remain out of the labor force ($j = 1$) or become employed ($j = 2$). An individual receives one new job offer at the beginning of each period with certainty and with no cost of search, so entering employment or changing jobs are always options.

The medical care alternatives available to an individual include any combination of physician visits and hospital nights up to a maximum of K each per period. The alternatives are denoted by v_t for the number of physician visits and k_t for the number of hospital nights. Purchase of medication and other medical expenses are not modeled. The indicator d_t^{jvk} equals one if employment alternative j, v doctor visits, and k hospital nights are chosen during period t, and zero otherwise, and $\mathbf{d}_t = (d_t^{jvk}, \forall j, v, k)$.

The health insurance coverage of individuals under age 65 is classified into one of the following seven categories: no insurance, own-employer health insurance with retiree benefits (EPRHI), spouse's employer health insurance, own-employer health insurance without retiree benefits (EPHI), private insurance, Medicaid, or Medicare. Although Medicaid provides free medical care to financially eligible individuals regardless of age, we do not account for the income and asset limits in our model. Medicare is available before age 65 only to men who have applied for and are enrolled in the Social Security Disability (SSDI) program. Upon becoming eligible for Medicare at age 65 a man is assumed to be covered by Medicare and may be covered by one other source.[10] We do not allow multiple sources of health insurance coverage before age 65 because doing so increases the complexity of the model substantially.[11]

As noted above, computational feasibility requires that we treat health insurance coverage as given. Thus, we assign a man his observed health insurance coverage and characteristics in the periods for which we have data. We assume that he expects his health insurance coverage to remain unchanged following the last period for which we have data. If an individual with own-employer insurance changes jobs, he is assumed to have health insurance on the new job, with characteristics (premium, deductible, etc.) assumed to be those of a "generic" plan described in the Appendix. Also, if an individual is covered by his employer's health insurance plan without retiree coverage, he becomes uninsured if he chooses nonemployment. He remains uninsured until he is observed to become employed again (with health insurance) or he reaches age 65 and receives Medicare coverage. Men with

[10] Men who report being covered by insurance from the Veteran's Administration or the Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) are classified as having employer-provided insurance with retiree benefits. Men who are observed to be on Medicare before age 65 are included in the analysis, but we do not model the decision to apply for SSDI.

[11] This assumption is relaxed in Blau and Gilleskie (2006), which estimates a model of the employment decisions of married couples.

Medicare coverage before age 65 are assumed to lose such coverage if they chose to become employed. Health insurance coverage of a man covered by his employer's plan with retiree insurance, by a spouse's employer's plan, or by a private plan is unaffected by his own employment decisions.

2.2. *State Variables and Laws of Motion.* The state variables characterize the information available to an individual at the beginning of a period. They determine his period t alternatives and/or the utility derived from each alternative in period t. The employment-related state variables and their laws of motion are

$$\text{employment state entering } t\text{: } e_{t-1} = \begin{cases} 1 & \text{if } d_{t-1}^{1vk} \neq 1 \\ 0 & \text{otherwise,} \end{cases}$$

$$\text{lay off indicator entering } t\text{: } f_t = \begin{cases} 1 & \text{if } e_{t-1} = 1 \text{ \& laid off entering } t \\ 0 & \text{otherwise,} \end{cases}$$

$$\text{work experience entering } t\text{: } x_t = \begin{cases} x_{t-1} & \text{if } d_{t-1}^{1vk} = 1 \\ x_{t-1} + 1 & \text{otherwise.} \end{cases}$$

The health states are good ($h_t = 0$), bad ($h_t = 1$), and deceased ($h_t = 2$). The health state in period $t + 1$ is determined by health in t, the medical care choices during period t, age, permanent unobserved heterogeneity, and an i.i.d. shock. The probability of making a transition from health state i in period t to health state a in period $t + 1$ is given by

$$(1) \quad \pi_{t+1}^{ia}(v_t, k_t \mid \mu)$$
$$= \text{pr}(h_{t+1} = a \mid h_t = i, v_t, k_t, A_t, \mu)$$
$$= \frac{\exp(\gamma_{0ia} + \gamma_{1ia} v_t + \gamma_{2ia} v_t^2 + \gamma_{3ia} k_t + \gamma_{4ia} k_t^2 + \gamma_{5ia} A_t + \rho_{1ia}\mu)}{\sum_{b=0}^{2} \exp(\gamma_{0ib} + \gamma_{1ib} v_t + \gamma_{2ib} v_t^2 + \gamma_{3ib} k_t + \gamma_{4ib} k_t^2 + \gamma_{5ib} A_t + \rho_{1ib}\mu)},$$

where $\pi_t^{i0} + \pi_t^{i1} + \pi_t^{i2} = 1\, \forall i, \forall t$ and A_t is age. Unobserved permanent individual differences affect the health transitions by means of an additive factor μ and its factor loading ρ. We do not impose a distribution on this unobserved heterogeneity, but rather assume it is discrete and estimate the mass points and their weights jointly with other parameters of the model. The vector of state variables[12] (known by the individual) at the beginning of period t is $\mathbf{s}_t = (e_{t-1}, f_t, x_t, h_t, \mathbf{Z}_t, \mu)$, where $\mathbf{Z}_t$ are exogenous characters.

[12] Four additional state variables are required in order to model the details of Social Security and pensions. These are the age at which an individual leaves the job held at the initial survey date, the age at which he begins his first nonemployment spell after age 61, a binary indicator of whether he ever re-enters employment following a nonemployment spell after age 61, and the number of consecutive nonemployment periods following such a return. The role of these variables is discussed in Appendices A2 and A3.

2.3. *Utility Function and Budget Constraint.* Per-period utility, conditional on being alive during the period, is defined for each employment (j) and utilization (v doctor visits and k hospital nights) alternative during period t. That is,

(2)

$$U(C_t, \mathbf{d}_t, \mathbf{s}_t, \epsilon_t) = \begin{cases} \alpha_{0,ie} + \dfrac{1}{\alpha_{1,ie}} C_t^{\alpha_{1,ie}} \\ \quad + e_{t-1}\big(\alpha_{2,i0} + \alpha_{3,i0} f_t + \alpha_{4,i1} d_t^{2vk} + \alpha_{5,i1} d_t^{3vk}\big) \\ \quad + (1 - e_{t-1})\big(\alpha_{6,i1} d_t^{2vk} A_t\big) \\ \quad + \alpha_{7,ie} v_t + \alpha_{8,ie} v_t^2 + \alpha_{9,ie} v_t A_t \\ \quad + \alpha_{10,ie} k_t + \alpha_{11,ie} k_t^2 + \alpha_{12,ie} k_t A_t \\ \quad + \alpha_{13,ie} A_t + \alpha_{14,ie} A_t^2 \\ \quad + \rho_{2ie}\mu + \rho_{3iv}\mu + \rho_{4ik}\mu + \epsilon_t^{ijvk} & \text{if } C_t > 0 \\ \alpha_{15,ie} & \text{if } C_t \le 0 \end{cases}$$

$$= \bar{U}_{jvk}^{i} + \epsilon_t^{ijvk}.$$

As indicated by the i and e subscripts on α, preferences differ by health ($h_t = i$) and by employment ($e_t = e$). C_t is consumption net of medical care expenditures and taxes. Utility is increasing and concave in consumption if $\alpha_{1,ie} < 1$, allowing for risk aversion. The constant relative risk aversion specification for consumption allows for the possibility that health insurance will be valuable to the individual, with risk-neutrality as a special case.

The utility constants measure the utility of a particular employment state when in good or bad health (α_0). For men who were previously employed, α_2 measures the utility of choosing nonemployment (depending on one's health state) and α_3 adjusts this utility if the individual chooses nonemployment following a layoff from his previous job. The utility of taking a new job and of staying on the same job are denoted by α_4 and α_5, respectively. Those who were previously nonemployed face utility costs that vary by age when re-entering the workforce (α_6). Medical care provides utility (or disutility) in both the good health and bad health states, with the marginal utility of a visit or night allowed to depend on health (i), employment status (e), and age. For a given age, the marginal utility of each type of medical care is decreasing if $\alpha_{7,ie} > 0, \alpha_{8,ie} < 0$ and $\alpha_{10,ie} > 0, \alpha_{11,ie} < 0$. The quadratic specification ensures a determinate solution for medical care choices.

Unobserved permanent heterogeneity alters utility each period as indicated by the additive μ terms. The factor loadings allow the effects to depend on the employment and medical care alternative selected.[13] $\epsilon_t = (\epsilon_t^{ijvk}, \forall i, j, v, k)$ is a vector of period t health- and alternative-specific utility shocks. If consumption falls below zero (i.e., if out-of-pocket medical expenses exceed after-tax income) for a given alternative, then individuals receive utility of $\alpha_{15,ie}$, a parameter to be estimated. This approach to modeling the consequences of negative income in the absence of a savings decision is based on Rust and Phelan (1997). As mentioned above, we do not allow for savings for reasons of computational feasibility.

The budget constraint is given by

$$C_t = w_t(1 - d_t^{1vk}) + b_t - m_t - \Gamma(w_t, b_t, m_t), \quad \forall t, j, v, k, \tag{3}$$

where w_t is earnings if employed in period t, b_t is nonwage income (benefits) in period t, m_t represents out-of-pocket medical expenditures at time t, and $\Gamma()$ is an income and payroll tax function that accounts for the medical expense deduction. Earnings may depend on experience, age, and exogenous characteristics ($\mathbf{Z}_t$), but are not stochastic: $w_t = w(x_t, A_t, \mathbf{Z}_t)$. We do not allow individuals to choose hours of work in response to a given hourly wage; rather, we assume that individuals are confronted with a take-it-or-leave-it salary offer. Rust (1990) shows that most of the variation in annual hours worked among older men is due to variation in employment status; variation in hours worked among the employed is quite small. Similarly, Hurd (1996) provides evidence that older workers tend to retire from full-time jobs, instead of gradually reducing their hours, in part due to labor market constraints that make part-time employment costly or unavailable. Benefits are given by $b_t = b(e_t, x_t, A_t, \mathbf{Z}_t)$, which incorporates many different sources of nonwage income. The Social Security benefit to which an individual is entitled at a given age is a function of his work experience and employment status at that age. The computation of Social Security benefits follows the formulas used by the Social Security Administration closely, although not exactly in every instance. The pension benefit may depend on an individual's age, experience, and employment status. Formulas derived from the plan descriptions provided by employers determine pension benefit amounts for every possible age and experience combination.[14] Nonwage income also includes earnings of the spouse,[15] income

[13] We allow the heterogeneity loadings in preferences to differ by employment, but make no distinction between new and old job, and to differ by no visits (nights) and any visits (nights), but not by the number of visits (nights).

[14] The pension benefit formula depends on the age of exit from the period $t = 1$ job, which is also a state variable.

[15] We assume in solution of the model that marital status is deterministic and known with perfect foresight for those periods in which it is observed. Additionally, we assume that once a man's marriage ends, for whatever reason including death of the spouse, he remains unmarried thereafter. (The marriage continuation rate from wave 1 to wave 2 was 0.959, with no obvious trend by age, implying a one-year continuation rate of 0.979.) Also, once a marriage dissolves, earnings from the spouse and health insurance from the spouse's employer are no longer available. In solution beyond those periods observed in the data, we assume marital status does not change from the status last observed.

from assets, and unemployment insurance. Details on each source of income are provided in the next section.[16]

Out-of-pocket medical expenses, m_t, depend on the number of physician visits and hospital nights chosen by the individual, the price per visit or per night, and the characteristics of health insurance coverage at the beginning of period t: $m_t = m(v_t, k_t, p_v, p_k, P)$, where the p's are per-visit or per-night prices and P is a vector of insurance plan cost-sharing characteristics. These characteristics include the premium, deductible, coinsurance rate, maximum out-of-pocket expenditure, and maximum insurance liability.

The expected present discounted value (EPDV) of lifetime utility from choosing employment state j and medical visits v and k in period $t < T^*$ given health status $i < 2$ (and conditional on permanent unobserved heterogeneity μ) is

$$(4)\quad \begin{aligned} &V^i_{jvk}(\mathbf{s}_t, \epsilon^i_t \mid \mu) \\ &= \bar{U}^i_{jvk} + \epsilon^{ijvk}_t + \beta\big[(1-\phi)\big[\pi^{i0}_{t+1}(v,k \mid \mu)V^0(f_{t+1}=0, \mathbf{s}_{t+1} \mid \mu) \\ &\qquad + \pi^{i1}_{t+1}(v,k \mid \mu)V^1(f_{t+1}=0, \mathbf{s}_{t+1} \mid \mu)\big] \\ &\qquad + \phi\big[\pi^{i0}_{t+1}(v,k \mid \mu)V^0(f_{t+1}=1, \mathbf{s}_{t+1} \mid \mu) \\ &\qquad + \pi^{i1}_{t+1}(v,k \mid \mu)V^1(f_{t+1}=1, \mathbf{s}_{t+1} \mid \mu)\big]\big] \\ &\qquad \forall j, v, k \text{ and } i = 0, 1, \end{aligned}$$

where $\bar{U}^i_{jvk}$ is the deterministic part of the utility of choosing alternatives j, v, and k in health state i during period t, conditional on permanent heterogeneity μ. β is the discount factor and ϕ is the probability of being laid off at the beginning of period $t+1$, if employed during period t. In the event of death at period t, the value function (which involves no choices and does not vary with observed or unobserved heterogeneity) is normalized to zero. Maximal expected utility of being in health state i in period $t+1$ (unconditional on choices at $t+1$) is $V^i(\mathbf{s}_{t+1} \mid \mu) = \mathrm{E}_t[\max V^i_{jvk}(\mathbf{s}_{t+1}, \epsilon^i_{t+1} \mid \mu), \forall j, v, k]$; this function is referred to as EMAX below.

2.4. *Solution.* Although T^* represents the end of life, we model individual decisions only to period $T < T^*$ for computational tractability. In the empirical analysis we set $T = 70$. Instead of modelling employment and medical care decisions for $t > T$, we follow Mroz and Weir (2003) and specify an approximation to the value function at T. In addition to computational considerations, our sample does not include individuals aged over T, so we would have little empirical

[16] Allowing earnings and benefits to be uncertain would require additional state variables, such as the Average Indexed Monthly Earnings (AIME) in the determination of Social Security benefits, and would result in additional computation cost, such as integration over the distribution of future earnings, which increases solution and estimation time considerably. The probability of being laid off, an important component of income uncertainty, is modeled.

basis for modeling the behavior of such individuals in any case. Thus, we specify $V(\mathbf{s}_T) = g(\mathbf{s}_T, \nu)$, where $g(\cdot)$ is a function of the state space at T, with parameters (ν) that are estimated jointly with the other parameters of the model.

The model is solved by backward recursion beginning at the terminal period T for a random subset of the state space. Following Keane and Wolpin (1994), we estimate a flexible regression function fitting the EMAX to the period t state variables. The estimated regression function approximates the EMAX at points in the state space for which the EMAX was not computed. Conditional on permanent unobserved heterogeneity, the only variables that are unobserved by the econometrician at t are the ϵ_t's. The assumption that the ϵ_t's are additively separable and independent and identically Extreme Value distributed yields a closed form solution for the EMAX, the expected maximum over all possible alternatives in period $t+1$. That is,

$$(5)\qquad V^i(\mathbf{s}_{t+1} \mid \mu) = \mathrm{E}_t\big[\max V^i_{jvk}\big(\mathbf{s}_{t+1}, \epsilon^i_{t+1} \,\big|\, \mu\big), \forall j, v, k\big]$$
$$= \gamma + \ln\left(\sum_{j=1}^{J(\mathbf{s}_{t+1})} \sum_{v=0}^{K} \sum_{k=0}^{K} \exp \bar{V}^i_{jvk}(\mathbf{s}_{t+1} \mid \mu)\right),$$

where γ denotes Euler's constant, $J(\mathbf{s}_t)$ indicates the number of employment alternatives (which is a function of the employment state entering the period), and $\bar{V}^i_{jvk}(\mathbf{s}_t \mid \mu) = V^i_{jvk}(\mathbf{s}_t, \epsilon_t \mid \mu) - \epsilon_t^{ijvk}$. Multi-dimensional integration over the distribution of $\boldsymbol{\epsilon}_t$ is avoided. It also follows from the assumptions about the ϵ's that the choice probabilities have the multinomial logit form

$$(6)\qquad \mathrm{p}\big(d_t^{jvk} = 1 \,\big|\, \mathbf{s}_t, \mu\big) = \frac{\exp\big(\bar{V}^i_{jvk}(\mathbf{s}_t \mid \mu)\big)}{\sum_{j'=1}^{J(\mathbf{s}_t)} \sum_{v'=0}^{K} \sum_{k'=0}^{K} \exp\big(\bar{V}^i_{j',v',k'}(\mathbf{s}_t \mid \mu)\big)} \forall t.$$

Solving backward yields the choice probabilities for each point in the state space in each period t. The additional probabilities used to form the likelihood function include the health transition probabilities (π_{t+1}) and the layoff probability (ϕ).

Other recent structural models of retirement do not have as detailed a specification of health insurance and medical expenditure as ours, but in some cases allow for a different set of employment alternatives. Gustman and Steinmeier (1994) do not allow any sources of risk, and do not model health, medical expenditures, or health insurance choice. They include part-time employment in the choice set but do not model job switching. Berkovec and Stern (1991) do not incorporate Social Security, pensions, or health insurance, but allow a richer employment choice set. Lumsdaine et al. (1994) value health insurance at average cost and do not model medical expenditures, health, or health insurance choice or availability. (They use data from a single firm.) Rust and Phelan (1997) allow for shocks to income, model part-time employment (but not job switching), and treat medical expenditure as the realization of an exogenous stochastic process. They exclude individuals with pensions and disability insurance. Finally, French (2005) allows for uncertainty in health and wages and models hours worked and savings, but does not consider medical care consumption decisions. Thus, we view the contribution of our work to be that of precisely modeling the budget constraint that individuals face with respect to health insurance and medical care consumption. For this reason, we solve the model for every individual in the data set, using the observed individual-specific values of characteristics (such as cost-sharing details of health insurance coverage, pension plan rules, and inputs to the Social Security income calculations) in each time period.

3. DATA

We use data from the first four waves of the Health and Retirement Study (HRS), fielded at two-year intervals beginning in 1992. The original HRS sample contains individuals aged 51–61 in 1992, and their spouses even if the spouses are outside the specified age range. We use the subsample of age-eligible men. The survey includes an employment history and extensive sections on pensions, health insurance, Social Security, earnings, assets, nonwage income, and health. Two additional sources of information have been matched to the survey responses. The Social Security earnings records of individuals who agreed to sign release forms were made available by the Social Security Administration. Individuals who reported being covered by a pension or by employer-provided health insurance were asked to provide the names and addresses of the firms that provide the coverage. These firms were surveyed by telephone and asked to provide details of health insurance plans over the telephone and to provide written descriptions of their pension plans. These supplementary sources of data provide crucial pieces of information that allow us to construct an accurate approximation to the budget constraint. However, they also limit the sample that we can use because there are many cases in which the supplementary information is unavailable.

Table 1 describes how we obtain the sample we use. Of the 5,867 men surveyed in 1992, 4,552 are age-eligible (51–61 in 1992). We lose about 15% of these men as a result of missing information on employment, demographic variables, and health, leaving 3,869 cases. Social Security records are available for 94.8% of these 3,869 men. Most of the cases without Social Security records are the result of the absence of a signed release, but some cases may be due to the fact that a man was never employed in a job covered by Social Security. This is difficult to determine so we drop all men without a Social Security record.

Of the men who reported being covered by an employer-provided health insurance plan from a current or former employer of their own or their wife, 68.3% have a record on the Health Insurance and Pension Provider Survey (HIPPS). Records are missing if the man did not provide a name and address for the relevant employer or if the employer did not respond to the request for an interview. There is also a substantial amount of missing health insurance information in the HIPPS records: over half are missing at least one piece of information that we need. The HRS interview asked respondents to provide some information about their health insurance, but did not include questions on the key variables we need, so we are forced to drop all cases with missing health insurance data.

TABLE 1
SAMPLE DERIVATION

Row	Description	Number	Percent
1	Men in the HRS	5,867	
2	Age-eligible men	4,552	77.6% of row 1
3	With complete data on key HRS variables (referred to as Full Sample)	3,869	85.0% of row 2
4	With a Social Security record	3,667	94.8% of row 3
5	With employer-provided health insurance at wave 1	2829	73.1% of row 3
6	With a HIPPS health insurance record	1,932	68.3% of row 5
7	With complete HIPPS health insurance data	686	35.5% of row 6
8	Covered by a pension at wave 1	2,655	68.6% of row 3
9	With a pension provider record	1,655	62.3% of row 8
10	With complete data from pension provider or missing information filled in from the HRS	1,655	100.0% of row 9
11	Estimation sample	1,167	30.1% of row 3

NOTE: The estimation sample consists of age-eligible men with complete data on key HRS variables, a Social Security record, no employer health insurance or employer health insurance with a complete HIPPS record, no pension coverage or a pension and either complete data from the pension provider or missing information filled in from the HRS.

Of the men who report being covered by a pension from a current or former employer, 62.3% can be matched to a written plan description provided by the employer. Over half of these descriptions are missing information that we need. However, the HRS asked respondents to provide a large amount of information about their pensions, and this allowed us to fill in missing data on pensions from former employers and, in some cases, current employers. The sample we use in estimation consists of 1,167 men who either provide complete information on pension or health insurance coverage or do not have a pension or health insurance. This is not a representative subsample from the HRS. As Table 2 indicates, men without pensions and without health insurance are overrepresented.

The following subsections describe the key variables.

3.1. *Employment Status.* We measure employment status at one-year intervals. The wave 1 survey provides information on employment status at wave 1, and the job history collected at wave 1 allows us to determine employment status one year prior to the date of the wave 1 interview. The surveys of subsequent waves give us a measure of employment status at that wave, and a monthly record of employment between the interviews provides the information needed to measure employment status at a date one year after the interview of the previous wave. Yearly employment transitions are preferred to two-year transitions in order to avoid underestimating labor force movements of older men (Blau, 1994). Employment status could be measured at finer intervals than one year, but we miss very few transitions by using one-year intervals (Blau and Gilleskie, 2001a). Table 3 displays the employment distributions in these eight years (1991–98) for the estimation sample and for the full sample. The employment rate in the estimation sample falls by 14.4 percentage points during this eight-year interval as the sample

TABLE 2
SAMPLE CHARACTERISTICS

Characteristic	Full Sample	Estimation Sample
Age	55.8	54.8
Education	12.3	11.9
Black	0.15	0.17
Hispanic	0.08	0.09
Married	0.81	0.75
Employer health insurance	0.73	0.44
With retiree coverage	0.79	0.84
Pension	0.69	0.56
Good health	0.79	0.74
Attrited by wave 2	0.09	0.07
Attrited by wave 3	0.24	0.22
Attrited by wave 4	0.29	0.28
Number	3,869	1,167

NOTE: At wave 1 survey unless otherwise noted. The full sample refers to the age-eligible men with no missing data on key variables in wave 1 and, if a nonattriter, in all subsequent waves of the HRS surveys. Data from all relevant waves are included in the analysis for attriters.

TABLE 3
EMPLOYMENT STATUS DISTRIBUTIONS

	Full Sample			Estimation Sample		
	Employed			Employed		
Description	Same Job	New Job	Not Employed	Same Job	New Job	Not Employed
1991 (1 year before wave 1 interview)	71.2	7.0	21.8	62.4	8.0	29.6
1992 (wave 1 interview date)	72.2	5.8	22.0	64.2	5.3	30.5
1993 (1 year after wave 1 interview)	68.8	7.3	23.9	62.0	8.7	29.3
1994 (wave 2 interview date)	66.0	5.9	28.1	60.1	6.8	33.1
1995 (1 year after wave 2 interview)	55.2	13.6	31.2	49.4	17.4	33.2
1996 (wave 3 interview date)	57.2	6.2	36.6	56.7	6.3	37.0
1997 (1 year after wave 3 interview)	49.0	13.1	37.9	44.4	15.6	40.0
1998 (wave 4 interview date)	51.1	5.7	43.2	49.5	6.5	44.0
Ever not employed		56.2			58.5	
Ever change jobs		26.9			30.6	
Ever enter employment		21.3			23.0	
Same job throughout		27.8			24.7	

ages from 50–60 years old (in 1991) to 57–67 years old (in 1998). About 58.5% of the estimation sample is not employed in at least one of the eight dates observed, some 30.6% ever change from one job to another, 23.0% ever enter employment from nonemployment, and 24.6% is employed at the same firm in all eight years.

The corresponding figures for the full sample show a little more job stability and less nonemployment.[17]

3.2. *Medical Care.* The HRS asks respondents to report the number of nights spent in the hospital and the number of times they have seen or talked to a medical doctor about their health, including emergency room or clinic visits, during the 12 months preceding the wave 1 interview and during the two-year interval between the subsequent interviews.[18] Over three-fourths of men had at least one doctor visit per year, but about 80% had no hospital nights. Among those in bad health, however, 84% have some doctor visits and 32% are hospitalized. Although less than 3% of those in good health are in the highest categories of visits (13+) and nights (11+) per year, men in bad health are four times more likely to be in these categories (not shown).

3.3. *Health.* The HRS has a rich set of health measures, including self-assessed general health and disability, functional limitations, chronic diseases, and many others. Despite this abundance of measures, we take a very simple approach to measuring health in order to focus on the economic aspects of the analysis and to avoid the proliferation of parameters and expansion of the state space that would result from exploiting the richness of the health data.[19] We create a dichotomous measure of health at each survey wave ($t = 2$, 4, 6, and 8) from responses to the question "Would you say your health is excellent, very good, good, fair, or poor?" by combining responses of excellent, very good, and good (good), and poor and fair (bad). We use the wave 1 ($t = 2$) health responses and responses from another wave 1 question "Compared with one year ago, would you say that your health is much better now, somewhat better now, about the same, somewhat worse, or much worse than it was then?" to construct a health measure for one year before wave 1 ($t = 1$). The analogous question in the survey at subsequent waves asks individuals to compare their current health to their health *two* years ago and therefore cannot be used to construct a health status measure in odd years beyond $t = 1$. Thus, in estimation of the model, we integrate over all possible health outcomes for years in which health is not observed. Table 4 suggests that the cross-sectional health distribution is stable over time (row percent), but there is a substantial amount of movement between health states. About 10–15% of men in good health fall into bad health by the next year, and 20–25% of men in bad health "recover" by the next year. Death rates increase across waves as the sample ages.

[17] The higher new job rates in periods 5 and 7 suggest a seam problem (Rust, 1990).

[18] In solution of the model, we assign half of the observed two-year medical care behavior to each of the corresponding two one-year choice periods (e.g., $t = 2$ and 3 for wave 2 data), and randomly assign the remainder when there is an odd number of visits or nights over the two-year period.

[19] See Wallace and Herzog (1995) for information on health measures in the HRS. Blau and Gilleskie (2001b) and Bound et al. (1999) provide detailed analyses of the effect of health on employment in the HRS. Deaton and Paxson (1998a, 1998b) find self-reported health to be a reliable predictor of mortality, with evidence also provided in the medical literature by Miilunpalo et al. (1997).

TABLE 4

HEALTH DISTRIBUTION AND TRANSITIONS

Period	Row Percent	Health Status		
		Good	Bad	Dead
$t = 1$			$t = 2$	
Good	73.8	90.1	9.9	0.0
Bad	26.2	25.2	74.8	0.0
$t = 2$			$t = 4$	
Good	73.3	90.2	9.5	0.3
Bad	26.7	21.7	76.9	1.4
$t = 4$			$t = 6$	
Good	71.7	89.4	9.4	1.2
Bad	28.3	24.9	64.6	10.5
$t = 6$			$t = 8$	
Good	74.8	83.2	15.1	1.7
Bad	25.2	19.1	73.2	7.7

TABLE 5

HEALTH INSURANCE DISTRIBUTION

	Wave 1 Ages 51–61	All Waves	
		Age $<$ 65	Age $\geq$ 65
EPRHI	31.9	33.4	3.4
EPHI	9.9	12.7	13.5
Spouse	7.6	8.0	8.4
Private	14.9	12.0	16.0
None	24.7	20.9	47.9
Medicaid	5.6	6.9	10.9
Medicare	5.4	6.0	–

NOTES: EPRHI = employer-provided retiree health insurance; EPHI = employer-provided health insurance. VA/CHAMPUS cases are classified as having EPRHI. All males are less than age 65 in Wave 1. All males age 65 and older are covered by Medicare; hence the last column represents supplemental coverage.

3.4. *Health Insurance.* We use the HRS data to classify individuals into one of the seven mutually exclusive and exhaustive health insurance categories shown in Table 5. Cases with multiple sources of insurance are assigned to categories in the order shown in the table. For example, a man with both employer-provided coverage and privately purchased coverage is assigned to employer coverage. The distribution of health insurance coverage (at wave 1) is skewed away from employer coverage in the estimation sample (compared to the full sample); this results from the large number of nonresponses and missing items from HIPPS.

We assign wave 1 insurance status to period 1, wave 2 insurance status to period 3, wave 3 to period 5, and wave 4 to period 7. We do not observe health

TABLE 6
HEALTH INSURANCE CHARACTERISTICS

Description	Proportion of Plans with Char Nonmissing	Proportion of Plans Char > 0	Conditional on Char > 0		
			Mean	Standard Deviation	Median
Premium					
Annual employee	0.98	0.48	522	720	335
Annual family	0.94	0.65	1,508	1,500	1,172
Average for employer-provided insurance*	1.00	0.53	868	1,066	480
Average for retiree insurance (EPRHI)*	0.84	0.58	1,094	1,294	552
Deductible					
Annual for all services*	1.00	0.62	291	822	200
Annual for office visits only	1.00	0.04	127	93	100
Copayment					
Flat amount per office visit	1.00	0.36	10	4	10
Percentage per office visit*	1.00	0.32	18	7	20
Flat amount per hospital stay	0.74	0.16	173	191	100
Percentage per hospital stay*	0.25	1.00	19	9	20
Annual amount for hospital stays	0.74	0.05	683	795	400
Maximum Deductible Amount					
Annual out-of-pocket max for office visits*	1.00	0.34	1,572	1,461	1,000
Annual out-of-pocket max for hospital stays*	0.99	0.34	1,652	1,389	1,200
Out-of-pocket max per hospital stay	1.00	0.02	666	586	413
Maximum Coverage Amount					
Annual maximum coverage limit*	0.65	0.99	67,450	129,920	50,000
Lifetime maximum coverage limit	0.64	0.95	1,011,603	507,093	1,000,000

NOTE: The sample consists of all cases with own or spouse employer health insurance, except where noted otherwise. Cases with VA/CHAMPUS coverage are not included in the descriptive statistics, but these cases are included in the analysis and are assigned the characteristics of VA/CHAMPUS coverage. *Characteristics used in generic plans when specific characteristics are not available (with the level set to the median).

insurance status in periods 2, 4, 6, and 8. As noted above, we assume health insurance in these periods (as well as that in periods beyond the sampling time frame) is the same as the last observed period unless an individual with own-employer coverage but no retiree health benefits chooses to leave employment or an individual under age 65 with Medicare chooses to take a job.

The HIPPS supplement from employers provides cost-sharing characteristics of health insurance plans such as the premium, deductible, coinsurance rate, maximum out-of-pocket costs, and maximum coverage. We use these characteristics, described in Table 6, in constructing the budget constraint. There is substantial variation across plans both in whether a given feature is present and the magnitude.

We observe the characteristics of employer insurance only for the insurance policy held by the man at the time of the wave 1 HRS interview in 1992. If a man subsequently changes employers or drops coverage from his own employer and picks up coverage from his wife's firm, we do not know the characteristics of the new health insurance plan. Therefore we specify "generic" employer health insurance plans (of each type EPRHI, EPHI, and spouse) with cost-sharing characteristics given by the median characteristics of the observed plans of that type.

Private insurance plans were not included in the HIPPS survey and the characteristics of such plans (except for the premium) were not recorded in the HRS, so we use another data source to construct a set of cost-sharing characteristics of a "generic" private plan, and assign these to all private plans (described in Section A of the Appendix). For Medicare coverage we use the Medicaire cost-sharing characteristics and incorporate rules governing the payment structure when individuals have a supplemental source of coverage. Medicaid coverage requires no cost-sharing by the recipient. The HRS lacks information on the price per doctor visit and hospital night, so we derive these measures from another data source (described in Section A of the Appendix).

3.5. *Pensions.* The HRS collects detailed data on pensions for all jobs that provide pension coverage. This includes information on the type of plan (defined benefit or defined contribution), years included in the plan, the respondent's current contribution rate, the age at which the respondent expects to receive benefits, the expected benefit amount, and various other features. These data provide a rich source of descriptive information, but do not include the actual formula used to determine the benefit as a function of age of exit from the firm, tenure, earnings, and so forth. The formula is needed in order to compute the benefit to which the respondent would be entitled at different ages of exit from the firm. In many cases the written plan descriptions sent to the HRS in response to the request made during the HIPPS telephone interview provide the information needed to construct the formula. Programmers at the Institute for Social Research at the University of Michigan coded the data from the plan descriptions into a computer program that computes the benefit to which the individual is entitled for specified quit dates from the firm providing the pension. We used this program together with the HRS survey responses to compute the benefit from the pension on the job held at period $t = 1$ (if any) for each possible quit date from 1991 until the respondent reaches age 70, treating job tenure at $t = 1$ as given.[20] Table 7 summarizes two key characteristics of pensions: the earliest age at which benefits can be collected and the benefit amount for alternative quit dates. The youngest age at which benefits can be collected is 57 on average, and the average return to postponing exit from the firm by one year is 2.6% in the first five years.

[20] We are grateful to Dan Hill and Jody Lamkin at ISR for their help with the program, and to Charlie Brown for advice on how to use it.

TABLE 7
PENSION CHARACTERISTICS

Description	Mean	Standard Deviation
$t = 1$ Job		
Youngest age at which benefits could be collected	57.0	3.8
Annual Benefit (if benefit>0 and age<71)		
if exit job in 1991	11,880	12,382
if exit job in 1996	13,517	14,722
if exit job in 2001	16,567	17,233
if exit job in 2006	20,556	20,755
if exit job in 2011	21,711	19,056
Previous Jobs		
Youngest age at which benefits could be collected	56.3	8.4
Annual Benefit (if benefit > 0)	11,761	13,200

NOTE: $ amounts measured in year 1992 dollars.

For pensions provided by previous employers we used the program to compute the benefit to which the individual would be entitled at the earliest age at which he is eligible for a benefit under the plan. We have information on up to three pension plans from the period 1 job and three pensions from previous employers. The HIPPS survey covers wave 1 employers and previous employers but does not include any new employers after wave 1. If a man took a job that provides pension coverage after wave 1 we have information from the wave 2, 3, and 4 survey about characteristics of the pension but no information on the benefit formula, since the new employer was not included in the HIPPS survey. Thus, we ignore pensions on jobs that begin after period $t = 1$. Additional information is provided in Section B of the Appendix.

3.6. *Earnings.* As noted above, we treat earnings as deterministic because of the added computational complexity of modeling earnings uncertainty. Aside from the risk of layoff, which we do model, we view earnings fluctuations as a relatively minor source of risk at older ages, compared to medical expenditures risk.[21] Consequently, the main issue for modeling earnings is how to obtain good forecasts to include in the model as a measure of individuals' expectations about their future earnings. We compared forecasts from earnings data derived from the HRS survey to forecasts derived from the Social Security Earnings Records (SSER). The HRS records annual earnings from jobs held each wave and up to two previous jobs, whereas the SSER file contains (truncated) annual earnings for every year in which an individual was employed on a covered job from 1951 through 1991. The earnings regressions based on the SSER data have a much

[21] A random effects panel data linear regression of earnings and medical care expenditures in logarithms for HRS men (white, 12 years of education, and married) reveals that the variance of the transitory component for earnings is 0.0172 whereas the variance of the transitory component for out-of-pocket medical expenditure is 1.110.

better fit. We set aside the last four years of data from the SSER, ran log earnings regressions using the earlier years, and used the regressions to forecast earnings for the last four years. We tried many different specifications and found that a first-order autoregression provided decent forecasts and additional lags of earnings reduced the median absolute forecast error by only a small amount. (See Section C of the Appendix for more detail.) Therefore, for individuals who remain on their $t = 1$ job, we use earnings in 1991 from the SSER file as our wage forecast for subsequent years. For individuals who become employed anytime after leaving their $t = 1$ jobs or who were not employed at $t = 1$, we predict wages using a regression function fit to the most recent SSER earnings, an indicator for a current period job change, and current period health.

We also used the SSER file to compute a measure of each man's total years of work experience through 1991. We use this file instead of the HRS survey responses to construct the experience measure because the HRS does not contain a compete work history from which total experience can be reconstructed, and the experience variable is used in the model only for constructing Social Security benefits. Mean experience through 1990 is 31.0 years with a standard deviation of 8.7.

3.7. *Social Security Benefits.* We use the SSER earnings history from 1951 through 1990 to construct each individual's Average Indexed Monthly Earnings (AIME) and Primary Insurance Amount (PIA) as of 1990, using the formula in effect for 1990. The PIA is the basis for computing the Social Security Benefit (SSB), and is a nonlinear, highly progressive function of the AIME, which is a wage-inflation-adjusted average of earnings from age 21 to the current age, minus the lowest five years of earnings. We then use the earnings measure described above to compute the AIME and PIA for each of the possible total number of years of experience the individual could accumulate from 1991 through age 70. A man who is aged 50 in 1991 could accumulate up to 21 additional years of experience if he worked every year from 1991 until the age of 70, so we compute 21 PIAs for such a man. We use these to compute the SSB for which a man would be eligible upon exiting the labor force for each possible number of years of experience from his age in 1991 through age 70. These benefit measures are based on the exact formulas used by the Social Security Administration (which differ by cohort as the 1983 Social Security reforms are phased in), accounting for reduced benefits for early retirement and increased benefits for delayed retirement. We assume that an individual who leaves the labor force after age 61 claims Social Security benefits.[22]

[22] Also, if a man exits the labor force, begins receiving his SSB, and then re-enters employment, his SSB when he exits employment the second time will be different from his first benefit because his PIA will be recomputed to give him credit for additional earnings, and any early retirement penalty he may have suffered will be modified. In order to use the exact formulas governing these recomputations it would be necessary to keep track of the actual sequence of employment choices from ages 62 through 70 instead of simply the cumulative number of periods of employment. This would increase the size of the state space substantially, so we use an approximation described in Section C of the Appendix.

TABLE 8

SOCIAL SECURITY MONTHLY PRIMARY INSURANCE AMOUNT FOR ALTERNATIVE YEARS OF WORK EXPERIENCE SINCE 1990

Description	Mean	Standard Deviation
PIA as of 1990	705	284
PIA after 5 additional years of work	742	292
PIA after 10 additional years of work	773	298
PIA after 15 additional years of work	809	308
PIA after 20 additional years of work	826	338

NOTE: The sample in each row includes only those men who are age 70 or younger after the indicated number of additional years of experience.

Finally, we compute benefits conditional on employment as well as nonemployment, applying the Social Security earnings test to determine the benefit entitlement conditional on being employed. This test, which is also cohort-specific, results in zero benefits for most men, but some low-earnings men have a positive benefit while employed.

Table 8 shows the average PIA as of 1990, as well as for various additional accumulated years of experience. To provide some sense of what these figures mean in terms of benefits, note that for the older cohorts in the sample a man who first begins collecting benefits at age 65 is entitled to a monthly benefit equal to the PIA; a man who begins collecting benefits at the earliest possible age (62) is entitled to a benefit equal to 80% of the PIA; and a man who postpones collecting benefits until age 70 is entitled to a benefit equal to 125% of the PIA.

3.8. *Other Nonwage Income.* Other sources of nonwage income include the earnings of the wife, asset income, and income from earnings-tested or means-tested government programs such as SSDI, Supplemental Security Income (SSI), or unemployment insurance. We sum all of these sources to create a single measure of other nonwage income, which we regress on polynomials in age and education. We use fitted values from these regressions as measures of other nonwage income for periods in which the data are not available. The regression results are in Section C of the Appendix.

We use the 1992 Federal income tax and payroll tax schedules to compute measures of after-tax income. The computations account for taxation of Social Security benefits, the medical expense deduction, and marriage.

3.9. *Likelihood Function.* Estimation of the model parameters involves maximizing the joint probability of the observed choices and outcomes in our HRS sample. The probabilities that form the likelihood function are derived from solution of the individual's optimization problem given his set of individual characteristics. From Equation (6), the joint probability that an individual chooses alternatives j, v, and k conditional on the state vector and unobserved heterogeneity is

$p(d_t^{jvk} = 1 \mid \mathbf{s}_t, \mu)$. The health transition probability (defined in Equation (1)) is denoted $\pi_{t+1}^{ia}(v_t, k_t \mid \mu)$ and is a function of the period t medical care choices v and k. The likelihood function includes $\Phi_t = (1-\phi)^{1-f_t}\phi^{f_t}$, where ϕ is the probability of being laid off and f_t indicates whether or not an individual is observed to be laid off at the beginning of period t. We also include initial employment and health state probabilities that depend on unobserved heterogeneity.

We observe the employment decisions and layoff indicators of individuals in every period. We observe annual medical care consumption (number of doctor visits and hospital nights) of individuals in period 1, but only observe the two-year sum of these choices in subsequent waves of the data. Because we distribute the reported two-year sum of each type of care over the relevant one-year periods, medical care utilization is observed in every period except the last year individuals are in the sample. The health state of individuals is known for periods 1, 2, 4, 6, and 8. We integrate over all possible health states if alive in periods 3, 5, and 7. If an individual dies, the period of death is observed. Finally, the likelihood contribution of those who attrit (for reasons other than death) is truncated at their last observed period. The vector $\boldsymbol{\Theta}$ includes all the parameters of the model, including the factor loadings (ρ) on the unobserved heterogeneity. The likelihood function contribution for individual n, conditional on the permanent unobserved heterogeneity, is

(7)

$$\begin{aligned}
&\mathcal{L}_n(\boldsymbol{\Theta} \mid \mu) \\
&= \prod_{i=0}^{1} p(h_1 = i \mid \mu)^{1(h_{n1}=i)} \\
&\cdot p(e_0 = 0 \mid \mu)^{1(e_{n0}=0)} p(e_0 = 1,\ f_1 = 0 \mid \mu)^{1(e_{n0}=1,\, f_{n1}=0)} \\
&\cdot p(e_0 = 1,\ f_1 = 1 \mid \mu)^{1(e_{n0}=1,\, f_{n1}=1)} \\
&\cdot \left[\prod_{j=1}^{J(s_1)} \prod_{v=0}^{K} \prod_{k=0}^{K} \Big[p\big(d_1^{jvk} = 1 \,\big|\, s_1, \mu\big)\pi_1^{ia}(v, k \mid \mu)\Big]^{d_{n1}^{jvk}}\right]^{1(h_{n1}=i, h_{n2}=a)} \\
&\cdot \prod_{t=2}^{T_n-2} \Bigg\{ \prod_{j=1}^{J(s_t)} \prod_{v=0}^{K} \prod_{k=0}^{K} \Big[\Phi_t p\big(d_t^{jvk} = 1 \mid s_t, \mu\big) \\
&\qquad \cdot \Bigg[\sum_{a'=0}^{1} \Bigg(\pi_t^{aa'}(v, k \mid \mu) \Bigg[\prod_{j'=1}^{J(s_{t+1})} \prod_{v'=0}^{K} \prod_{k'=0}^{K} \\
&\qquad \cdot \big[\Phi_{t+1} p\big(d_{t+1}^{j'v'k'} = 1 \,\big|\, s_{t+1}, \mu\big)\pi_{t+1}^{a'a''}(v', k' \mid \mu)\big]^{d_{n3}^{j'v'k'}}\Bigg]^{1(h_{nt+2} = a'')}\Bigg)\Bigg]^{1(h_{nt+1} \neq 2)}
\end{aligned}$$

$$\cdot \left[\pi_t^{a2}(v, k \mid \mu)\right]^{1(h_{t+1}=2)} \Bigg]^{d_{nt}^{jvk}} \Bigg\}$$

$$\cdot \left[\prod_{j=1}^{J(s_{T_n})} \sum_{v=0}^{K} \sum_{k=0}^{K} \left[\Phi_{T_n} \mathrm{p}\left(d_T^{jvk} = 1 \mid s_{T_n}, \mu\right)\right]^{d_{nT_n}^{jvk}} \right]^{1(h_{nT_n}=i)}$$

where lines 2–4 of Equation (7) give the probability of being observed in a particular health and employment state entering period 1 (the initial conditions). Line 5 is the likelihood of the first period employment and medical care decisions and the subsequent observed health transition. Lines 6–9 summarize behavior prior to 1997 in two-year intervals. Here, health is observed in the latter year, but is not observed (unless the individual dies), and is therefore integrated out, in the first of these two years. The last line of the likelihood function includes the probability of the last observed employment choice and integrates over the distribution of medical care choices since they are not observed. Health transitions following the last observed employment choice are also not observed. The unconditional likelihood contribution of individual n is

$$\mathcal{L}_n(\Theta, \theta) = \sum_{m=1}^{M} \theta_m \mathcal{L}_n(\Theta \mid \mu_m) \tag{8}$$

where θ_m is the estimated probability of mass point m, $m = 1, \ldots, M$ of the support of the unobserved heterogeneity distribution. The likelihood for the entire sample is

$$\mathcal{L}(\Theta, \theta) = \prod_{n=1}^{N} \mathcal{L}_n(\Theta, \theta). \tag{9}$$

Identification is achieved through variation in individual choices and outcomes, economic constraints embedded in the model, and parametric assumptions. Utility function parameters reflecting different payoffs for different alternatives are identified by variation in choices across individuals. The productive effects of medical care are identified by individuals in different health states selecting different levels of inputs and arriving at different health states in the subsequent period. Observed death dates also help to identify the health transition probabilities. The budget and health insurance constraints identify the risk aversion parameter. That is, some men have health insurance options that are tied to work and others do not. Some individuals have access to pensions and some do not. Differences in experience and age of entitlement determine differences in Social Security income. Finally, the assumption of no serial correlation in errors, conditional on the permanent unobserved heterogeneity, provides a source of identification, as variation in the entire sequence of past choices and outcomes serves to identify the model.

4. ESTIMATION RESULTS

4.1. *Parameter Estimates.* Table 9 displays the estimated values and standard errors of utility function parameters. The coefficient of relative risk aversion ($1 - \alpha_{1,ie}$) differs by health and employment status. The estimated values are between 0.960 and 0.989, indicating that individuals are moderately averse to risk.[23] These values are similar to Rust and Phelan's (1997) estimate of 1.072 and Hurd's (1989) estimates of 0.73 and 1.12.

In order to identify preferences, we normalize the utility intercept associated with good health and not working ($\alpha_{0,00}$). Relative to nonemployment while in good health, working (unconditional on the employment transition) provides lower utility. Bad health reduces the utility of both employment and nonemployment. Interestingly, working while in bad health provides higher utility than not working. The utility of employment declines with age at an increasing rate ($\alpha_{13,ie}$ and $\alpha_{14,ie}$). Nonemployment at younger ages (early 50s) creates disutility regardless of health, but working becomes relatively less attractive as one ages Utility also depends on the employment transition and its interaction with health ($\alpha_{2,ie}$ through $\alpha_{6,ie}$) and therefore is not completely captured by the intercepts and age effects.

Conditional on age, the utility of doctor visits is positive but decreases with each additional visit. Visits are more utility enhancing (or less utility decreasing) for individuals in bad health versus those in good health ($\alpha_{7,ie}$ and $\alpha_{8,ie}$). Hospital stays reduce utility for individuals in good health, but increase utility at low levels of utilization for those in bad health ($\alpha_{10,ie}$ and $\alpha_{11,ie}$). As individuals age, the utility of medical care consumption increases. The utility of nonpositive consumption is negative and large ($\alpha_{15,ie}$) and always less than the utility of positive consumption regardless of health and employment or medical care choices. The estimated health transition rates reflect worsening health as individuals age. Medical care improves health on average but the quantitative effects are negligible. Estimates of parameters of the health transitions, final period value function, initial health and employment, and unobserved heterogeneity are listed in Appendix Table A.1.

4.2. *Model Fit.* Simulated choice probabilities derived from solution of the model are compared to the data in Tables 10–12.[24] The model provides a good fit to the employment distribution in general (Table 10). Conditional on previous employment status, the model accurately predicts most transitions, but tends to overpredict transitions to employment from nonemployment. The estimated model captures the main features of the distribution of office visits, with some

[23] These coefficients also suggest that the marginal utility of consumption is higher in good health (as opposed to bad health) when working and not working. Gilleskie (1998) also found the marginal utility of consumption to be smaller during episodes of acute illness than in periods of wellness among working men. Rust and Phelan (1997), on the other hand, found the marginal utility of consumption to be greater in poorer health (unconditional on employment status) in their model of retirement behavior.

[24] We simulate behavior until age 70 using observed characteristics of each of the 1,167 individuals in our estimation sample and 10 different sets of draws from the unobservables. Hence the simulated sample size is 11,670.

TABLE 9

ESTIMATION RESULTS—UTILITY FUNCTION PARAMETERS

Description			Parameter	Estimate	Standard Error
Utility Constants					
Good health	nonemployed[a]		$\alpha_{0,00}$	25.000	–
Good health	employed		$\alpha_{0,01}$	22.120	0.1677
Bad health	nonemployed		$\alpha_{0,10}$	6.263	0.0611
Bad health	employed		$\alpha_{0,11}$	14.143	0.1322
Consumption					
Good health	nonemployed		$\alpha_{1,00}$	0.027	0.0001
Good health	employed		$\alpha_{1,01}$	0.040	0.0004
Bad health	nonemployed		$\alpha_{1,10}$	0.011	0.0001
Bad health	employed		$\alpha_{1,11}$	0.019	0.0003
Employment Transitions					
Good health	nonemployed	from employed	$\alpha_{2,00}$	−0.491	0.0026
good health	nonemployed	from laid off	$\alpha_{3,00}$	0.652	0.0042
Good health	employed (new job)	from employed	$\alpha_{4,01}$	−0.696	0.0051
Good health	employed (same job)	from employed	$\alpha_{5,01}$	1.650	0.0108
Good health	employed (new job) * age	from nonemployed	$\alpha_{6,01}$	−0.037	0.0004
Bad health	nonemployed	from employed	$\alpha_{2,10}$	−1.373	0.0111
Bad health	nonemployed	from laid off	$\alpha_{3,10}$	1.303	0.0089
Bad health	employed (new job)	from employed	$\alpha_{4,11}$	−1.793	0.0133
Bad health	employed (same job)	from employed	$\alpha_{5,11}$	0.574	0.0065
Bad health	employed (new job) * age	from nonemployed	$\alpha_{6,11}$	−0.073	0.0003
Medical Care Use					
Good health	visits		$\alpha_{7,0e}$	0.072	0.0005
Good health	visits^2		$\alpha_{8,0e}$	−0.019	0.0001
Good health	visits * age		$\alpha_{9,0e}$	0.0008	0.0001
Bad health	visits		$\alpha_{7,1e}$	0.211	0.0009
Bad health	visits^2		$\alpha_{8,1e}$	−0.005	0.0001
Bad health	visits * age		$\alpha_{9,1e}$	0.0022	0.0002
Good health	nights		$\alpha_{10,0e}$	0.011	0.0001
Good health	nights^2		$\alpha_{11,0e}$	−0.219	0.0005
Good health	nights * age		$\alpha_{12,0e}$	0.0007	0.0001
Bad health	nights		$\alpha_{10,1e}$	0.030	0.0002
Bad health	nights^2		$\alpha_{11,1e}$	−0.004	0.0001
Bad health	nights * age		$\alpha_{12,1e}$	0.0001	0.0001
Demographic Preference Shifters					
Good health	nonemployed	age	$\alpha_{13,00}$	−2.649	0.0007
Good health	nonemployed	age^2/100	$\alpha_{14,00}$	0.306	0.0024
Good health	employed	age	$\alpha_{13,01}$	−2.195	0.0019
Good health	employed	age^2/100	$\alpha_{14,01}$	−0.115	0.0007
Bad health	nonemployed	age	$\alpha_{13,10}$	−3.119	0.0037
Bad health	nonemployed	age^2/100	$\alpha_{14,10}$	0.004	0.0001
Bad health	employed	age	$\alpha_{13,11}$	−2.758	0.0026
Bad health	employed	age^2/100	$\alpha_{14,11}$	−0.052	0.0004
Utility of nonpositive consumption			$\alpha_{15,ie}$	−86.223	0.1534

[a]Parameter $\alpha_{0,00}$ fixed.

TABLE 10

PERCENT DISTRIBUTION OF OBSERVED AND PREDICTED EMPLOYMENT BEHAVIOR

Behavior	Observed	Predicted
Unconditional on Previous Employment		
Not employed	33.80	30.61
Employed in new job	8.97	11.77
Employed in same job	57.23	57.62
Conditional on Being Employed in previous period		
Not employed	8.45	7.01
Employed in new job	8.26	8.93
Employed in same job	83.28	84.05
Conditional on Being Nonemployed in previous period		
Not employed	89.48	84.87
Employed in new job	10.52	15.13
Ever nonemployed	58.54	57.35
Ever changed jobs	30.62	42.45
Ever enter employment	23.04	33.86
Always on same job	24.66	14.75

TABLE 11

PERCENT DISTRIBUTION OF OBSERVED AND PREDICTED MEDICAL CARE UTILIZATION

Doctor Visits	Observed	Predicted	Hospital Nights	Observed	Predicted
		Unconditional on Health Status			
0	22.20	20.07	0	81.35	61.06
1–2	36.78	26.19	1–3	10.72	30.31
3–5	22.68	27.95	4–10	5.27	6.94
6–12	13.44	19.77	11+	2.66	1.70
13+	4.90	6.02			
		Conditional on Good Health			
0	25.82	24.42	0	87.09	69.75
1–2	40.68	30.83	1–3	8.44	29.91
3–5	20.73	30.73	4–10	2.97	0.10
6–12	9.80	14.01	11+	1.50	0.23
13+	2.97	0.01			
		Conditional on Bad Health			
0	16.17	6.75	0	67.96	34.43
1–2	22.55	11.99	1–3	13.37	31.50
3–5	25.75	19.42	4–10	12.08	27.88
6–12	24.25	37.40	11+	6.59	6.17
13+	11.28	24.43			

tendency to overpredict the two highest categories (Table 11). The probability of any hospital nights during the year is overpredicted. These patterns also appear when the predictions are disaggregated by health status. The model's estimates of health transitions rates by health status and age accurately reflect diminishing health as individuals age (not shown).

TABLE 12

EMPLOYMENT CHOICES BY HEALTH INSURANCE STATUS, AGE < 65

	Observed Employment Choice			Predicted Employment Choice		
Health Insurance	Non Empl	New Job	Same Job	Non Empl	New Job	Same Job
EPRHI	21.43	5.80	72.76	27.63	10.28	62.08
EPHI	8.35	8.35	83.30	5.69	10.64	83.67
Spouse	32.66	10.44	56.90	41.46	9.66	62.08
Private	24.61	22.82	52.57	23.93	12.27	63.80
None	27.71	23.21	49.09	28.18	15.10	56.72
Medicaid	89.45	3.12	7.42	49.47	12.28	38.24
Medicare	91.80	4.51	3.69	85.95	10.07	3.98

NOTES: EPRHI = employer-provided retiree health insurance; EPHI = employer-provided health insurance.

Table 12 demonstrates that the model captures employment behavior by health insurance status quite well in general. The predicted employment choices reflect the fact that there is greater attachment to a job if the individual holds EPHI only instead of also having access to retiree health insurance (EPRHI). Similarly, a man is more likely to leave an employer if he is covered by his spouse's employer or private health insurance than if he has EPHI. We do not model the income and asset restrictions for eligibility for Medicaid and, hence, overpredict employment while covered by Medicaid. Similarly, we do not model the avenues for Medicare coverage prior to age 65 (e.g., specific severe illnesses and disability income receipt), but do impose the constraint that individuals cannot be employed and covered by Medicare while under age 65. The model does a good job of capturing the nonemployment choices of those individuals. The model's ability to capture the employment patterns by health insurance suggests that the restriction imposed by the model—that health insurance affects behavior only via the budget constraint and risk aversion—is reasonable.[25]

Comparisons of predicted and actual employment choices of individuals at each observed age provides further evidence of the model's fit (not displayed). Consistent with the comparisons of Table 10, the model overpredicts job changes and re-employment at early ages. However, the model captures the large increase in the nonemployment rate at age 62 (with an observed hazard of 14.5% and a predicted 11.9% hazard). The employment exit behavior is consistent with eligibility for Social Security early retirement benefits at age 62. A second large exodus from employment at age 65 is not captured well by the model. Note, however, that the observed sample size at ages above 62 is less than 200 men. Although men without EPRHI begin exiting the labor force prior to age 65, their rate of departure is much smaller than men with retiree health benefits (not displayed). In fact, the

[25] In our work that models the joint retirement behavior of couples, we are similarly able to explain the differences in employment patterns of men with and without EPRHI by aversion to medical expenditure risk. However, this explanation accounts for only one-third of these differences among women (Blau and Gilleskie, 2006).

TABLE 13

SIMULATED EMPLOYMENT CHOICE PROBABILITIES UNDER DIFFERENT SCENARIOS

	Baseline		Simulation 1: Add EPRHI to Employer Plans		Simulation 2: Eliminate EPRHI from Employer Plans		Simulation 3: No Health Insurance Before Age 65		Simulation 4: Universal Insurance Before Age 65	
Group	Non Empl	Same Job	Non Empl	Same Job	Non Empl	Same Job	Non Empl	Same Job	Non Empl	Same Job
Unconditional on previous employment										
All	0.322	0.565	0.327	0.561	0.311	0.576	0.314	0.568	0.319	0.572
EPRHI	0.314	0.588	0.316	0.586	0.267	0.631	0.309	0.589	0.311	0.590
EPHI	0.073	0.825	0.109	0.789	0.068	0.830	0.109	0.787	0.114	0.784
EPRHI, good health	0.265	0.626	0.266	0.625	0.225	0.662	0.262	0.628	0.260	0.629
EPHI, good health	0.069	0.827	0.091	0.804	0.065	0.831	0.094	0.801	0.091	0.803
EPRHI, bad health	0.477	0.462	0.483	0.456	0.403	0.528	0.469	0.455	0.485	0.456
EPHI, bad health	0.089	0.819	0.190	0.727	0.083	0.826	0.177	0.724	0.223	0.695
Conditional on being employed in the previous period										
All	0.079	0.819	0.080	0.818	0.077	0.821	0.083	0.812	0.078	0.824
EPRHI	0.084	0.824	0.084	0.824	0.073	0.833	0.086	0.819	0.083	0.825
EPHI	0.053	0.853	0.060	0.847	0.049	0.856	0.062	0.841	0.059	0.848
EPRHI, good health	0.067	0.838	0.067	0.838	0.060	0.844	0.069	0.835	0.065	0.839
EPHI, good health	0.047	0.857	0.051	0.854	0.044	0.859	0.053	0.851	0.049	0.855
EPRHI, bad health	0.153	0.766	0.155	0.765	0.124	0.792	0.157	0.751	0.157	0.764
EPHI, bad health	0.077	0.836	0.100	0.817	0.072	0.841	0.107	0.794	0.109	0.808

trend toward increasing nonemployment probabilities begins as early as age 57 for those covered by retiree health insurance. In the next section, we determine how much of this observed difference is explained by health insurance status.

4.3. *Alternative Policy Scenarios.* Having estimated the structural parameters of our model, we are able to simulate behavioral responses to changes in policy variables of interest. We simulate behavior for each individual from his period $t = 1$ age (ranging from 50 to 60 in the sample) to age 70 under different policy scenarios. The state space is updated each period to reflect the simulated employment and medical care choices, health, and layoff status. The alternative scenarios we consider include adding retiree health insurance to all employer plans, eliminating retiree health insurance from employer plans, providing universal health insurance that is not tied to employment, and changing the age of Social Security and Medicare eligibility.

Columns 1 and 2 of Table 13 display the baseline probabilities of being nonemployed and of staying on the same job for all men, unconditional on previous employment (top panel) and conditional on being employed in the previous period (bottom panel). The rows of each table distinguish behavior by health insurance status and health status. We focus on individuals under age 65 who have coverage from their employer, as we are interested in whether EPRHI affects employment probabilities prior to availability of Medicare. The nonemployment rate averages 0.322 among men aged 50 to 64. Men with EPRHI are four times more likely to be nonemployed than men with EPHI only (0.314 vs. 0.073). Men with EPRHI who are in bad health are twice as likely to be nonemployed as men with EPHRI who are in good health (0.477 vs. 0.265). Although men in good health with EPRHI are four times as likely as those without EPRHI to be nonemployed (0.265 vs. 0.069), those in bad health are over five times as likely (0.477 vs. 0.089).

In order to determine how much of the difference in observed behavior is explained by retiree health insurance, we simulate behavior when EPRHI is added to all employer health insurance plans that do not provide it (simulation 1) and when EPRHI is eliminated from all employer plans that do provide it (simulation 2). Overall we see a slight increase from 0.322 to 0.327 (1.5%) in nonemployment rates when all employer health insurance plans offer retiree health insurance, and a small decrease to 0.311 (3.4%) when it is eliminated. However, when we condition on health insurance status, men who gain EPRHI increase their nonemployment rate by 50% (from 0.073 to 0.109) and men who lose EPRHI reduce their rate by 15% (from 0.314 to 0.267).[26] When we condition on health status, there is a more dramatic shift in behavior. The nonemployment rate doubles for those in bad health who gain EPRHI (from 0.089 to 0.190) while the increase is about 32% for those in good health (from 0.069 to 0.091). The reduction in the nonemployment rate among those who lose EPRHI is about 15% regardless of health status (from 0.483 to 0.403 and from 0.265 to 0.225).

These employment effects are driven, to some extent, by strong state dependence. That is, once an individual stops working, he is likely to remain in the nonemployment state. Conditional on employment in the previous period (bottom panel of Table 13), the annual exit rate from employment increases by less than one percentage point for men who gain EPRHI (from 0.053 to 0.060) and decreases by one percentage point for men who lose EPRHI (from 0.084 to 0.073). Disaggregated by health, we find that employment behavior of previously employed men with and without EPRHI who are in good health changes only slightly (less than 10% in the expected directions) when their health insurance changes. However, the exit rate of previously employed men in bad health increases by 30% (from 0.077 to 0.100) if they gain EPRHI and declines by almost 20% (from 0.155 to 0.124) if they lose EPRHI coverage.

In order to further understand how aversion to medical expenditure risk explains employment decisions, we consider a scenario in which no one has health insurance prior to age 65 (simulation 3) and one in which universal health insurance is provided (simulation 4). The universal plan has generous cost-sharing characteristics ($100 deductible, 20% coinsurance rate, $1,000 maximum deductible amount, and a $200 premium). Overall there is a negligible difference in the nonemployment rates with no health insurance and universal health insurance. There is a modest effect among those in bad health. This simulation suggests that

[26] Note that in simulation of the model beyond ages observed in the data, health insurance is assumed to be whatever was last observed in the data, and is consistent with the current employment choice. That is, if an individual was last observed to have EPHI, then he is assumed to take a job with EPHI if he ever re-enters employment beyond ages observed in the sample. An individual who is observed to have EPHI at some point in the data and who subsequently is observed to leave his employer and lose his health insurance (i.e., become uninsured) would be uninsured if he re-enters employment beyond the observed ages.

health insurance modestly affects employment decisions of older men in general, with a more sizable impact on those in bad health.

Other policy scenarios that we simulated (but do not include in the table) included raising the age of Medicare and Social Security eligibility to 67, both separately and together. Increasing the age of SS eligibility led to a significant reduction in the nonemployment rate. However, raising the age of Medicare eligibility only, which should shed more light on the importance of health insurance in explaining the employment patterns of the elderly, produced little change in employment behavior.

The estimated effects of EPRHI that we find here are smaller than the effects reported in our earlier paper (Blau and Gilleskie, 2001a).[27] That paper estimated an approximation to the structural model that did not allow us to identify the source of the EPRHI effect. Here, we restrict EPRHI to affect behavior only through aversion to medical expenditure risk and through health production via medical care utilization decisions. Other mechanisms through which EPRHI may affect behavior exist. For example, prescription drug utilization, nutrition, and exercise are not modeled here. If EPRHI facilitates use of prescription medication and the effect of this medical input on health transitions at older ages is significant, then we are missing an important effect of insurance. Similarly, if EPRHI has nonpecuniary characteristics that define its value to a consumer and that encourage effective utilization (i.e., provider choice and filing of claims), then the value of insurance may be understated. Finally, if health insurance influences the quality of care received, then we may not fully measure its effects on behavior. These are potentially important aspects of health and health insurance that could be incorporated into future models of employment behavior.

5. CONCLUSION

Simulations from our estimated model imply that changes in health insurance, including access and restrictions to retiree health insurance, have only a modest impact on the employment behavior of older males. The impact is markedly larger, however, for those in poor health. In general, the effects we find are small, and are smaller than those found by Rust and Phelan (1997). Several factors may account for this difference: We have more recent data; we have information on pensions, which allows for a more representative sample; and we model medical care utilization decisions.

Our model confirms a role for health insurance, especially if health is poor, but restricts the avenues through which health insurance affects behavior to the budget constraint, aversion to risk, and health production (via medical care use). Although we have not explored whether health insurance operates through any other mechanism, we are able to explain much of the differences in employment behavior by health insurance through these mechanisms.

[27] French and Jones (2004) similarly conclude that health insurance does not provide large retirement incentives.

Our results are based on the assumption that health insurance coverage is exogenous except when one's employment decision results in loss of insurance. We suspect that relaxation of this assumption is likely to reduce the impact of health insurance on employment decisions. A richer model that accounts for health insurance availability and choice is an important avenue for future research.

APPENDIX

A. HEALTH INSURANCE

A.1. *Data from health insurance providers.* Names and addresses of 4,487 establishments with health insurance plans covering an HRS respondent were obtained from the respondents in the wave 1 survey. Of these, 3,350 responded to the HIPPS telephone survey, yielding a file with observations on 6,505 plans (spouses covered by the same plan each have their own record with identical data). Multiple sources of health insurance are not uncommon, but allowing multiple sources of insurance complicates our model considerably. Some 430 individuals are covered by more than one plan from a given employer.[28] However, the survey does not provide any information on interactions between the plans. We decided to ignore multiple plans and use the "best" plan available for a given individual, where best is defined by the most generous coverage. If an employer had multiple health insurance plans and the HRS respondent did not provide enough information to identify which of the plans covered him, interviewers requested information on the plan used by most employees at the firm. The HIPPS file includes data only on those plans that appear to match a plan reported by an HRS respondent. Information about "cafeteria" plans was not elicited. Information was collected on age and tenure requirements that an employee must satisfy in order to be eligible for retiree coverage, but these data have not been coded.

A.2. *Generic health insurance plan characteristics.* If a man is ever observed to have a health insurance plan from an employer other than the HIPPS job or a type of health insurance different from the HIPPS job, then we assign him the characteristics of a generic plan of the type chosen. Because most individuals in our sample who have a complete HIPPS record have a deductible that applies to all services (see Table 6), we specify a deductible of this type for the generic plan and set it equal to the median deductible observed in the HIPPS data ($200). Similarly, the generic coinsurance rate is set to 20%, the maximum deductible amount for office visits is $1,000, the maximum deductible amount (per year) for hospital stays is $1,200, and the maximum annual coverage is $50,000. The average

[28] About 8% of men with EPRHI coverage also have coverage from the spouse's employer; 4.7% have Medicare coverage in addition to own-employer coverage; and 9% have private coverage in addition to own-employer coverage. About 4% of men with EPHI also have coverage from the spouse's employer, and 12% have private coverage in addition to own-employer coverage. About 7% of men with coverage from a spouse's employer also have coverage from their own employer, 12% have Medicare or Medicaid, and 13% have private coverage in addition to spouse-employer coverage. Five percent of men with private coverage also have coverage from Medicare or Medicaid.

TABLE A.1

ESTIMATION RESULTS—ADDITIONAL PARAMETERS

Description		Parameter	Estimate	Standard Error
Health Transition Probability Parameters				
Transitions from good to good health				
Constant		$\gamma_{0,00}$	11.2979	0.0499
Visits		$\gamma_{1,00}$	0.0011	0.0002
Visits^2		$\gamma_{2,00}$	−0.0001	0.0000
Nights		$\gamma_{3,00}$	0.0005	0.0000
Nights^2		$\gamma_{4,00}$	−0.0000	0.0000
Age		$\gamma_{5,00}$	−0.1084	0.0043
Transitions from good to bad health				
Constant		$\gamma_{0,01}$	6.8029	0.0516
Visits		$\gamma_{1,01}$	−0.0007	0.0001
Visits^2		$\gamma_{2,01}$	0.0001	0.0000
Nights		$\gamma_{3,01}$	−0.0006	0.0001
Nights^2		$\gamma_{4,01}$	0.0001	0.0000
Age		$\gamma_{5,01}$	−0.0702	0.0035
Transitions from bad to good health				
Constant		$\gamma_{0,10}$	9.2588	0.0531
Visits		$\gamma_{1,10}$	0.0009	0.0002
Visits^2		$\gamma_{2,10}$	−0.0001	0.0000
Nights		$\gamma_{3,10}$	0.0005	0.0001
Nights^2		$\gamma_{4,10}$	−0.0000	0.0000
Age		$\gamma_{5,10}$	−0.1205	0.0017
Transitions from bad to bad health				
Constant		$\gamma_{0,11}$	9.4053	0.0539
Visits		$\gamma_{1,11}$	0.0009	0.0002
Visits^2		$\gamma_{2,11}$	−0.0001	0.0000
Nights		$\gamma_{3,11}$	0.0003	0.0000
Nights^2		$\gamma_{4,11}$	−0.0000	0.0000
Age		$\gamma_{5,11}$	−0.1071	0.0010
Final Period Value Function Parameters				
Exponential constant if in good health		ν_{0e}	9.291	0.0688
Exponential constant if in bad health		ν_{1e}	5.745	0.0497
Other Parameters[a]				
Logit coeff for layoff probability		ϕ	−3.476	–
Discount factor		β	0.975	–
Initial Condition Parameters				
Logit coeff for good health (vs. bad health)			1.263	0.0014
Multinomial logit coeff for nonemployed (vs. employed & laidoff)			2.759	0.0031
Multinomial logit coeff for employed (vs. employed & laidoff)			3.921	0.0046
Unobserved Heterogeneity Parameters				
Factor Loadings Affecting				
Health transitions	Good to good health	ρ_{100}	0.216	0.0003
Health transitions	Good to bad health	ρ_{101}	−0.035	0.0001
Health transitions	Bad to good health	ρ_{110}	−0.024	0.0002
Health transitions	Bad to bad health	ρ_{111}	0.146	0.0002
Preferences for work	Good health, nonemployed[a]	ρ_{200}	1.000	–
Preferences for work	Good health, employed	ρ_{201}	−0.006	0.0001

TABLE A.1
CONTINUED

Description		Parameter	Estimate	Standard Error
Preferences for work	Bad health, nonemployed	ρ_{210}	0.013	0.0002
Preferences for work	Bad health, employed	ρ_{211}	0.014	0.0001
Preferences for any visits	Good health, nonemployed	ρ_{300}	0.007	0.0001
Preferences for any visits	Good health, employed	ρ_{301}	0.003	0.0001
Preferences for any visits	Bad health, nonemployed	ρ_{310}	−0.019	0.0002
Preferences for any visits	Bad health, employed	ρ_{311}	−0.001	0.0001
Preferences for any nights	Good health, nonemployed	ρ_{400}	0.010	0.0002
Preferences for any nights	Good health, employed	ρ_{401}	0.005	0.0001
Preferences for any nights	Bad health, nonemployed	ρ_{410}	−0.001	0.0001
Preferences for any nights	Bad health, employed	ρ_{411}	0.008	0.0001
Initial good health		ρ_{51}	0.0001	0.0000
Initially nonemployed		ρ_{52}	0.0001	0.0000
Initially employed (& not laid off)		ρ_{53}	0.0001	0.0000
Heterogeneity Distribution[b]				
Coeff for estimated mass point 2			0.450	0.0004
Coeff for estimated weight on mass point 1			1.650	0.0014
Coeff for estimated weight on mass point 2			0.054	0.0001
$\ln\mathcal{L}(\Theta) = -27813.850$				

NOTE: [a]Parameter fixed. [b]The coefficients are intercepts in logit and multinomial logit probabilities. Mass point 1 is fixed at 0 and mass point 3 is fixed at 1. Mass point 2 is 0.612 = exp(0.450)/(1 + exp(0.450). The probabilities of mass points 0, 0.612, and 1 are 0.717, 0.145, and 0.138, respectively.

annual premium for plans without retiree health insurance is $480 and for plans with retiree coverage is $552.

A.3. *Private health insurance characteristics.* The characteristics of the private health insurance plan (except for the premium) are obtained from private plans held by individuals in the 1987 National Medical Expenditure Survey (NMES) data. The deductible is $100, the coinsurance rate is 20%, the maximum deductible amount is $1,000, and the maximum amount covered is $100,000. The premium is obtained from the responses to the wave 1 HRS survey from those respondents who had private coverage, and is set to $1,870, the average premium reported.

A.4. *Medicare characteristics.* We use characteristics of Medicare that were in place as of 1994. There is no premium for Part A, which provides coverage for hospitalization. Coverage is provided for up to 90 days of inpatient care during each benefit period, where a benefit period begins on entry to a hospital and ends 60 days after the individual was last in a hospital or skilled nursing facility. The deductible for inpatient hospital care is $696. Days 1–60 in a hospital are fully covered once the deductible is met. Days 61–90 require a copayment of $174 per day. There is a lifetime reserve of 60 days of inpatient coverage that can be applied to hospital stays that exceed 90 days during a benefit period. For simplicity, we assume that the lifetime reserve is available every year. Part B provides supplementary insurance for physician care, and has a monthly premium of \$41.10, an annual deductible of \$100, and a coinsurance rate of 20%. Part B coverage is optional but we assume that all men take it up. (In 1992, 96% of all eligible individuals enrolled in part B of Medicare.) Medicare is the primary payer for retirees, and is the secondary payer for workers and their spouses aged 65 and over who elect to be covered by employer-provided health insurance by a firm with at least 20 employees. Employer-provided retiree coverage converts to "Medigap" coverage at age 65 and becomes the secondary payer, while employer-provided coverage for active employees remains the primary payer as long as the worker remains employed by the firm providing the coverage.

A.5. *VA/CHAMPUS characteristics.* This program helps veterans pay for civilian medical care when military care is not available. There is no premium, an annual deductible of \$150, a coinsurance rate of 25% for outpatient care, and a copayment of min(\$360/day, 25%) for inpatient care. Coverage is available regardless of employment status, and the coverage integrates with Medicare at age 65 in the same way as any other health insurance plan.

A.6. *Medicaid characteristics.* Publicly funded health care is available to all individuals who qualify for Medicaid. The means-tested program has income and asset limits that differ in each U.S. state. We do not model qualification for Medicaid and simply assume it is held when observed in the data. There is no cost-sharing required by Medicaid.

A.7. *Medical care prices.* Prices for medical care services are calculated from charges for every medical care service received by NMES respondents in 1987. The per visit price of \$65 reflects the 1987 average price for a physician office visit among males 50 years old and older. The price per hospital night, \$1,210, is obtained similarly. The corresponding prices in 1992 dollars are \$96 and \$1,765, using the medical care price index to adjust for inflation.

B. PENSIONS

The Pension Provider Survey (PPS) obtained written plan descriptions for 6,381 pension plans. The plan characteristics were coded by the Institute for Social Research (ISR) at the University of Michigan into a computer program that calculates benefits under alternative scenarios. For jobs held one year before the wave 1 survey ($t = 1$), we used the program to compute the benefit to which a man would be entitled for every possible year in which he could leave the firm, from $t = 1$ until he reaches age 70. The program takes as input the man's age and tenure with the firm as of $t = 1$, and his annual earnings for 1991 as reported by him in the wave 1 survey. Earnings are assumed to be constant in real terms after 1991. For jobs held prior to $t = 1$, we used the program to compute the benefit available at the earliest age of benefit availability, taking as input his tenure and annual earnings at the time he left the firm. Benefits are computed for both defined benefit and defined contribution plans, with benefits for the latter expressed in the form of an annuity. Benefits are computed for as many as three different plans from the $t = 1$ job and three different plans from previous jobs.

The HRS asked respondents to report the age at which they expect to start receiving benefits and the benefit amount for every pension plan for which they are or will be eligible for a benefit. We used these data to fill in missing values for pension benefits and age of eligibility for jobs held prior to $t = 1$, since the respondent's employment decisions from then on do not affect the benefit amount from jobs held prior to period 1. These data are not sufficient to fill in missing information for pensions on jobs held at $t = 1$, since benefits from such jobs depend on the man's employment decisions via the benefit formula, which we do not have in such cases.

In order to use the PPS data we have to keep track of the age at which an individual leaves the job held at $t = 1$ in the solution to the DP problem. This is therefore a state variable for men who are covered by a pension at the $t =$ 1 job.

C. EARNINGS AND SOCIAL SECURITY BENEFITS

C.1. *Wage earnings.* Earnings (w_t) of employed males who change jobs or who were not employed at $t = 1$ and take a new job are estimated outside the model and are a function of the most recent measure of earnings from the individuals SSER file (w_0). We also include an indicator for a new job and health status. The fitted values from this regression are used in solution to the model. Standard errors are in parentheses.

$$\begin{array}{l} \hat{w}_t = 6{,}061 + 411 * \dfrac{w_0}{1{,}000} + 14 * d_t^{2vk} + 6{,}106 * \mathbf{1}(h_t = 0) \\ \qquad\quad (12{,}933)\ (158) \qquad\qquad\quad (2{,}659) \quad (3{,}309) \end{array}$$

Mean positive earnings are \$26,000 and the standard deviation is \$15,695.[29]

C.2. *Other nonwage income.* Nonwage income (b_t) other than Social Security and pension benefits is assigned from the fitted values of the following regressions, which were estimated on the samples with positive values of nonwage income, defined as the sum of spouse's income, asset income, means-tested income, and

[29] The earnings records in the SSER file are truncated at the maximum taxable annual earnings.

annuities. The variables (s)age and (s)educ are the age and education of the man (his spouse).

$$\text{Not married, not employed}: \frac{\hat{b}_t}{10,000} = 2.7076 - 0.0196 * \text{age} - 0.2686 * \text{educ} + 0.0174 * \text{educ}^2$$

$$\text{Not married, employed}: \frac{\hat{b}_t}{10,000} = 0.7990 - 0.0188 * \text{age} - 0.3933 * \text{educ} + 0.0279 * \text{educ}^2$$

$$\text{Married, not employed}: \frac{\hat{b}_t}{10,000} = 2.2774 - 0.0069 * \text{sage} - 0.2993 * \text{seduc} + 0.0246 * \text{seduc}^2$$

$$\text{Married, employed}: \frac{\hat{b}_t}{10,000} = -1.9730 + 0.0736 * \text{sage} + 0.1159 * \text{seduc} + 0.0261 * \text{seduc}^2 - 0.0079 * \text{sage} * \text{seduc}$$

Some men had no nonwage income and were excluded from the regressions. These men were assigned zero nonwage income in the periods in which zero was observed only. Mean observed other nonwage income (over all ages) was $9,479 (with a standard deviation of $19,265) for nonemployed, unmarried men and $15,883 ($55,104) for employed, unmarried men. For married males, the figures were $20,026 ($24,068) and $24,473 ($27,352).

C.3. *Social Security benefits.* As described in the text, the first time a man is not employed and at least 62 years old his Social Security Benefit (SSB) is computed using the exact formula for men of his cohort. The formula is cohort-specific as a result of the 1983 reforms that gradually increase the normal age of retirement to 67 and phase in other changes as well. We use the 1992 formula for each cohort.

If a man who experiences a nonemployment spell at age 62 or older re-enters the labor force, the SSB for which he is eligible when he exits employment again can be computed using the exact formula only by making the complete sequence of employment choices from age 62 on a state variable. This makes the state space too large for solution of the DP problem. Instead we proceed as follows. First we use the exact formula to calculate the benefit for which a man would be eligible for every possible employment sequence involving re-entry after age 62. We then regressed the benefit on the PIA corresponding to the cumulative years of experience associated with the sequence at the time of re-exit, with separate regressions for each age of re-exit. Cumulative experience is a state variable, and the PIA associated with each possible level of cumulative experience is part of the data set. We use the fitted values from these regressions to assign the SSB for nonemployment spells that follow a spell of employment that itself followed a spell of nonemployment from age 62 on (i.e., individuals in their second nonemployment spell after age 61). Letting the form of the regression be SSB = a + b ∗ PIA, the results are listed below.

Age	a	b	R^2	|res|
63	12.481	0.779	0.996	1.0
64	13.171	0.811	0.979	4.0
65	12.876	0.844	0.955	7.1
66	14.465	0.884	0.935	6.0
67	14.909	0.915	0.917	7.0
68	15.528	0.944	0.897	7.3
69	14.805	0.974	0.874	7.6
70	13.294	1.005	0.850	9.1

|res| = Mean absolute value of the residual as a percent of the dependent variable.

In order to follow this approach we have to keep track of whether a given sequence of states involves a man re-entering employment following a nonemployment spell after age 61. This increases the size of the state space but not by as much as keeping track of the exact employment sequence. Therefore the state vector includes a binary indicator of whether a man ever re-enters employment following a nonemployment spell after age 61. We also account for the age at which an individual who has experienced employment after receiving Social Security benefits re-exits the workforce in determining his benefit calculation.

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