Retirement and the Demand for Health

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Abstract

This paper investigates the effect of allowing for endogeneous retirement in a life-cycle health production model with uncertainty. In particular, we study responses to changes in health insurance over the life-cycle and how retirement affects the price elasticity of the demand for health.

Keywords: demand for health, retirement, health insurance, price elasticity
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1 Introduction

In this paper, we extend the health production model due to Grossman (1972) in two directions. First, we introduce retirement and a relatively realistic Social Security system. Second, we allow for both unemployment risk and health shock risk simultaneously where unemployment risk is tied to the availability of health insurance prior to Medicare eligibility. We calibrate the model using data from the U.S. on asset accumulation, medical expenditures and retirement. This allows to simulate the response of life-cycle medical consumption to changes in health insurance.

Upon calibration of the model, we find plausible price elasticicies of the demand for health which are in the range of estimated elasticities in the literature. The model also yields that health expenditures are more elastic at younger ages than at older ages and that individuals self-insure against health risks by accumulating more assets. We also find that the price elasticity of the demand for health depends in part on whether endogeneous retirement is possible. When retirement is endogeneous, permanent changes in co-insurance rates have less of an impact on the demand for health because individuals can retire earlier or later to partially adjust life-time income.

The paper is organized as follows. In section 2, we first present the basic mechanism of Grossman's original investment model and then discuss how retirement has been introduced into the model. In section 3, we present the model we propose. Section 4 discusses calibration of the model to U.S. data. In section 5, we present results of simulations from the model. Finally section 6 concludes.

2 Demand for Health

Grossman (1972) presents a dynamic model of health production that views health as a stock rather than a flow. The basic insight from the model is that individuals demand health rather than medical consumption per se. Grossman distinguishes between two versions of the model: a consumption model where health yields utility directly and an investment model where health expands consumption possibilities, say by increasing earnings. In the basic investment model, the demand for health is determined by one key condition which equates the marginal benefit to the user cost of health investment. This equation can be expressed at age a as:

$$w_H(H_a) = \frac{\mu_m}{\theta}(r + \delta_a) \tag{1}$$

where $w_H(H_a)$ is the marginal productivity of health (H_a) in terms of earnings, μ_m is the price of medical care, θ the productivity of medical care and r and δ_a are the interest rate and the depreciation rate of health capital at age a. A key result is that optimal health may decrease with age while investment increases. A sufficient condition for health to decrease over the life cycle is that δ_a increases with age. For gross health investment to increase over the life-cycle, the elasticity of $w_H(H_a)$ must be less than one. This result is due to both a demand and a supply effect. The demand for health decreases as depreciation (δ_a) increases. On the other hand, the amount of health supplied for a given amount of investment decreases as well. If the supply effect dominates the demand effect, gross health investment increases over the life-cycle.

This simple optimality condition also allows to investigate the effect of shifts in prices and productivity on health and health investment. If $w_H(H_a)$ is negative in H_a (e.g. diminishing marginal productivity of health on earnings), an increase in the price of medical care will lower the demand for health while an increase in productivity of medical care will increase that demand.

As it turns out, the initial health endowment, H_0, is very important for the life-cycle path of the demand for health. Since gross investment in health is constrainted to be non-negative, individuals may not invest in health if "optimal" health is lower than their current health (depreciated). In other words, individuals will not invest in health at levels H_a when condition (1) yields $H^*_{a+1} \leq (1 - \delta_a)H_a$. As health depreciates, the individual will eventually reach an age beyond which next period health $(1-\delta_a)H_a$ in the absence of investment would fall below H^*_{a+1}. Hence, investment in health becomes positive beyond that point. That turning point can be used as a proxy for retirement. Retirement consists of a discrete change in the allocation of time and often occurs for health reasons. Wolf (1985) conceptualizes the age of retirement as the age when investment begins:[1]

$$R_a = \min\left\{a : w_H(\textstyle\prod_{s=0}^{a}(1-\delta_s)H_0) = \dfrac{\mu_m}{\theta}(r+\delta_a)\right\}.$$

This formulation highlights that conceptually retirement can be thought of as a period of life where individuals move away from investing in other forms of capital (assets) to focus on health investment. It also highlights that (i) individuals with higher depreciation rates will likely retire earlier and that (ii) the more expensive is medical care, the later retirement will occur.

However, this formulation of retirement fails to explain the fact that individuals invest in health throughout the life-cycle and not only after retirement. Furthermore, retirement decisions generally involve other considerations than health investment. For example, the timing of retirement generally affects life-time resources available for consumption. Galama, Kapteyn, Fonseca and Michaud (2008) extend the basic model to include a distinct retirement decision. Pension benefits are made function of life-time earnings and the timing of retirement. An analytical solution for the time-path of the demand for health is derived. A key result is that the demand for health is lower after retirement than before because income after retirement only depends in pre-retirement earnings. Hence, in the pure investment model, there are no benefits to investing in health after retirement. In the consumption model, i.e. where health enters the utility function, health investment is positive but lower than before retirement.

A key motivation for investing in health at older ages is that agents are subject to health shocks. Hence, they need to "repair their bodies" in order to stay alive. Furthermore, when not sick, they have incentives to maintain their health at a higher level than without uncertainty. Following Cropper (1977), a number of papers introduce health shocks as a source of uncertainty (Dardanoni and Wagstaff, 1987; Picone, Uribe and Wilson,1998; Liljas, 1998). If investment in health reduces the probability of becoming ill, this is effectively equivalent to raising the marginal benefit of investing in health, the left-hand side of condition (1), without affecting the right-hand side. Hence, it increases the demand for health.[2]

[1] $\prod$ is the product operator.
[2] Grossman himself noted this likely effect of introducing uncertainty in his 1972 article.

Once uncertainty is introduced, analytical solutions in the retirement model are more difficult to obtain. In this paper, we combine endogeneous retirement with uncertainty, both in health and employment status, and solve the model numerically to obtain a solution for the demand for health. We calibrate the model to data from the U.S. for non-hispanic white males with high school education or less. This allows to neglect a number of sources of heterogeneity, like education, which would make the model more complicated. We then look at interactions between retirement and the demand for health when varying the price of medical care.

3 Model

Decisions and Preferences At each age a, we assume an individual makes three decisions $d_a = (c_a, m_a, r_a)$. He chooses non-medical consumption c_a, medical consumption m_a and retirement status r_a. If he is retired, $r_a = 1$ and if not $r_a = 0$. One restriction on the choice set is that retirement is possible starting at age 55 to age 70. Furthermore, m_a is non-negative.

Preferences are assumed represented by the following utility function

$$U(c_a, h_a, r_a) = \frac{(c_a^{\gamma_c} h_a^{1-\gamma_c})^{1-\sigma} - 1}{1-\sigma} + \psi(a)L(r_a). \tag{2}$$

The parameter $\gamma_c \in (0,1)$ captures the share of consumption in the sub-utility function and $\sigma > 0$ governs the curvature. This first part of the utility function is the same as that adopted in Picone et al. (1998). The utility function is assumed to be separable in consumption and leisure. However, the marginal utility of leisure is assumed to depend on age. The function $L(r_a)$ represents leisure available as a function of retirement status. The constant relative risk aversion parameter is given by $-(\gamma_c(1-\sigma)-1)$, given health fixed, and consumption and health are complements for $\sigma < 1$ and substitutes when $\sigma > 1$.[3]

We assume individuals have a bequest motive following French (2005). When an individual dies at age a (which occurs when $h_a \leq H_{\min}$), he leaves a bequest,

[3] Dardanoni (1988) defines risk aversion measures when uncertainty is with respect to health only. In that case the coefficient of relative risk aversion is $R^R = \gamma_c - \sigma(\gamma_c - 1)$.

in terms of accumulated assets A_a, which yields utility,

$$b(A_a) = \theta_b \frac{(A_a + K)^{\gamma_c(1-\sigma)} - 1}{1-\sigma}. \tag{3}$$

The parameter θ_b denotes the importance of the bequest motive while $K \geq 0$ controls the curvature of the bequest function.

Assets At each age, individuals can decide to forgo consumption and invest instead in a composite asset A_a with annual return τ. We specify a standard intertemporal budget constraint following Hubbard, Skinner and Zeldes (1995). Cash-on-hand x_a is the sum of last-period assets including the return $(1+\tau)A_a$ and income $y_a(r_a)$. Expenditures include consumption c_a and out-of-pocket medical expenditures oop_a. We assume individuals are liquidity constrained such that they are not allowed net borrowing. End of period assets are given by

$$A_{a+1} = x_a + tr_a - c_a - oop_a, \quad A_{a+1} \geq 0 \tag{4}$$

Transfers tr_a are modelled in a simplified manner. We assume transfers (Suplemental Security Income, temporary assitance for needy families (TANF), food stamps, housing benefits) are given so as to guarantee a minimum consumption level, before medical decisions are made.

$$tr_a = \max(c_{\min} - x_a, 0)$$

We set $c_{\min} = \$7,000$ as in Hubbard, Skinner and Zeldes (1995). Since eligibility to transfers is a necessary condition for eligibility to Medicaid, we assume that those who have positive transfers are also eligible to Medicaid. In that case, Medicaid pays for out-of-pocket medical expenditures. Hence $oop_a = 0$ when $tr_a > 0$.

Income A household has three sources of income: earnings, retirement income and other income (income from other family members). If working, individuals collect *earnings* w_a which are assumed to be a function of age and the health stock. If working, log earnings are assumed given by

$$\log(w_a) = \eta_0 + \eta_1 age + \eta_2 age^2 + \eta_3 \log(H_a) \tag{5}$$

where η_3 denotes the elasticity of wages to the health stock, H_a. *Other income* is given by a simple quadratic function in age $sp_a = sp(a)$.Note that given uncertainty in health, earnings are uncertain.

Retirement income consist of Social Security benefits. Prior to the early retirement age of 62 for Social Security, there is no retirement income. Hence, retiring prior to 62 implies that consumption is financed through accumulated wealth. If the individual retires prior to 62, we assume Social Security benefit receipt starts at age 62. If the individual delays retirement past 62, we apply Social Security rules to adjust the benefits for delayed claiming (delayed retirement credit). Denote by ss_a social security benefits. These benefits depend on a measure of lifetime earnings, the average indexed monthly earnings $AIME_a$, and the age of retirement. Once an individual retires, we adjust his $AIME_a$ so as to reflect the actuarial adjustment if retirement does not occur at the Normal Retirement Age (NRA).[4]

Since the $AIME$ depends on the entire earning history, it would be computationally prohibitive to carry the entire earning history in the state space. Following Rust, Buchinsky and Benitez-Silva (2001), we approximate the $AIME$ using a smooth function of past $AIME$, earnings and age. The function can be represented as

$$AIME_{a+1} = G(AIME_a, w_a, age, r_a; \varsigma_a), \tag{6}$$

where ς_a denotes the parameters of that function at age a. We give detail on the estimation of that function in the next section.

Household income is given by

$$y_a(r_a) = T_a\left[w_a(r_a), ss_a(r_a), sp_a, \tau A_a\right], \tag{7}$$

where $T_a()$ denotes a tax function that for the U.S. takes account of federal taxes, partial taxation of retirement income and basic exemptions/credits.

[4] As in French (2005), the actuarial adjustment is applied on the PIA, a piece-wise linear concave function of the $AIME$. We use that function to back out the change in $AIME$ that is equivalent to the change in PIA.

Medical expenditures Out-of-pocket medical expenditures oop_a depend on employment status e_a (1 if employed, 0 if not) and age. We assume an individual who is unemployed and not Medicare eligible does not have health insurance. However, if eligible for transfers, Medicaid picks up medical bills. Those working have employer provided health insurance and those who are older than 65 have Medicare. In both of these cases, we use a standard health insurance contract with a deductible and co-insurance rate to transforms consumption into expenditures. We do the same for those on Medicare using deductible and co-pay amounts that reflect the Medicare part A and B price scedule. The function for those not Medicare or Medicaid eligible is given by

$$oop_a(m_a, e_a) = \begin{cases} \min(m_a, \mu_{1a}) + \mu_{2a} \max(m_a - \mu_{1a}, 0) & \text{if } e_a = 1 \\ m_a & \text{if } e_a = 0 \end{cases} \tag{8}$$

where (μ_{1a}, μ_{2a}) are the corresponding deductible and co-insurance rate respectively if covered at age a.

Health Production The stock of health is assumed bounded with minimum level $H_{\min}$ and a maximum of 100 units, $H_a \in [H_{\min}, 100]$. The choice of units is somewhat arbitrary but the 0-100 scale is a natural one. Each period, before decisions are made, a realization of the health shock ε_a can deplete the health stock. The severity of the health shock is set to λ. Health at the beginning of a period is $h_a = H_a - \lambda\varepsilon_a$. If this health falls below $H_{\min}$ the individual dies. Each period, the stock depreciates with a factor $1 - \delta_a$ where δ_a is specified as

$$\delta_a = 1 - \delta_1 \exp(\delta_2 age) \tag{9}$$

with $\delta_1, \delta_2 > 0$.

Following Picone et al. (1998), we assume a health production function of the form

$$I(m_a, \varepsilon_a) = \exp(\theta_1 + \theta_2\varepsilon_a) m_a^{\theta_3} / \theta_3 \tag{10}$$

The parameter θ_1 is a scale factor of efficiency of medical consumption and the parameter θ_3 governs the diminishing returns of medical investment. If a health shock occurs, we assume that productivity of medical consumption increased by a factor θ_2. This implies individuals have an additional incentive to consume medical care when they experience a shock.

With these assumptions, end of period health is given by

$$H_{a+1} = I(m_a, \varepsilon_a) + \delta_a \; H_a - \lambda \varepsilon_a \tag{11}$$

Uncertainty We introduce uncertainty along two dimensions, health and employment. First, we assume individuals face the risk each period of having a health shock. The probability of a health shock increases with age, as a result of the natural aging process, and the stock of health. Hence, individuals can affect the arrival rate of health shocks by investing in health. We assume the arrival probability of a health shock is

$$P(\varepsilon_{a+1} = 1 \mid age, H_a) = \Lambda(\pi_0 + \pi_1 \log(H_a) + \pi_2 age + \pi_3 age^2) \tag{12}$$

where Λ is the logistic cumulate distribution function (CDF).

Similarly, we assume individuals loose and find jobs stochastically. Job loss and job finding occurs with probability

$$P(e_{a+1} = j \mid age, e_a = k) = \Lambda(\omega_{k0} + \omega_{k1} age) \tag{13}$$

Solution of Dynamic Problem Individuals maximize the discounted sum of utility flows using a discount factor β. The Bellman equation for choice at age a is written as

$$\begin{aligned} V(S_a) &= \max_{d_a \in D(S_a)} U(c_a, h_a, r_a) + \beta \sum_{\varepsilon=0,1} P(\varepsilon_{a+1} = \varepsilon \mid age, H_a) \qquad (14) \\ &\quad \times \left[\begin{array}{c} s_{a+1}(\varepsilon) \sum_{e=0,1} V(S_{a+1} | e_{a+1} = e) P(e_{a+1} = e \mid age, e_a) \\ +(1 - s_{a+1}(\varepsilon)) b(A_{a+1}) \end{array} \right] \end{aligned}$$

where $s_{a+1}(\varepsilon) = I(h_a > H_{\min})$ denotes whether the individual is alive at $a+1$ given the realization of the shocks. The state space is represented by $S_a = (age, A_a, H_a, AIME_a, r_{a-1}, e_a, \varepsilon_a)$.Equation 14 is maximized subject to constraints (4) to (11).

This problem can be solved for the optimal solution: $\{d_a^*(S_a), V_a^*(S_a)\}_{a=1,\dots,A}$ by backward recursion. We assume the terminal age is 100 and the starting age is 25. We assume everyone who alive in the last period dies. Because some of the state variables are continuous (assets, health and $AIME$), we define a tri-dimensional grid over that space. We select 20 points for health and assets and 35 for $AIME$. Since decision rules are likely more non-linear at low values of assets and health, we set the grid in terms of equally spaced points on the log-scale. This yields a grid with 14000 nodes for each employment, retirement and health shock combination. We solve for the value and decisions at each point on that space. Since we have two continuous control variables, we define a grid for each of these decisions. We define those in turn of next period's assets and health status using the boundary conditions along with cash on hand, and depreciation to define the achievable states next period. We use intrapolation to calculate next period's value function when the solution for consumption and medical expenditure does not fall on the grid. Since we use a equally-spaced grid, we use a tri-dimensional cubic spline approximation proposed by Habermann and Kindermann (2007). When retirement is an option, we compute the optimal solution for each option and compare value functions to calculate $r_a^*(S_a)$.

Simulation We simulate hypothetical individuals by first drawing initial conditions from the joint distribution of AIME, assets and health at age 25. We then apply decision rules and update the state-space at each age until individuals reach age 100. We draw unemployment and health shocks from their respective distributions. Since the state at each age might not fall on the grid, we use intrapolation for consumption, medical expenditure and retirement decisions. We do this for 1000 hypothetical individuals.

4 Data and Calibration

We focus on describing the behavior of a relatively homogeneous group when calibrating the model. We selected non-hispanic white men. Women frequently exit voluntarily from the labor force at younger ages because of childbearing and such dimensions of choice are beyond the scope of this paper. Also, we focus on low educated individuals to avoid modelling the heterogeneity in behavior across education groups. We focus on non-hispanic white men for the same reason.

We use two sources of data to calibrate the model. The first is the Panel Study of Income Dynamics (PSID), from 1980 to 2003 which we use for labor force status, health status, earnings and assets. The PSID containts asset information in special wealth modules fielded in 1984,1989,1994,1999, 2001 and 2003. For medical expenditures, we use the Medical Expenditure Panel Survey (MEPS) for the years 2000 to 2003. Finally, we use earnings records of respondents to the Health and Retirement Study to estimate the relationship between $AIME$ and earnings.

Assets We estimate asset age profiles using the PSID. Assets include all real and financial assets minus debt. We express all monetary amounts in dollars of 2004. We estimate a median regression model of the form

$$Q_{0.5}(A_a|age, cohort, hhsize) = \alpha_0 + \alpha_a + \lambda_{cohort} + \beta hhsize_a \qquad (15)$$

where we control for 5-year cohort fixed effects (λ_{cohort}) and household size. Upon estimation we predict for household size of 3 born between 1936 and 1940.

Health Stock The health stock H_a is clearly a latent variable. Health is multidimensional and there does not exist a unique scale on which it can be measured. However, proxies of health exist to describe the "health stock" of an individual at any point in time. Because many of the profiles we consider (earnings or health shock) depend on the health stock, such an index is needed. We have measures of health shocks as well as subjective measures of general health and disability. One way to proceed is to consider the health stock as a latent variable and estimate a multiple indictator model for each process. Another approach is simply to construct a health index from various indicators and plug-in such indices in our processes (Meijer, Kapteyn and Andreyeva, 2008; Michaud and van Soest, 2008). This is the approach we follow. In particular, we isolate the first factor from three general measures of health: self-reported health on a 5 point scale, a general disability question and the body-mass index. This score has mean zero and variance 1 by construction. We then scale the score to lie between 0 and 100. Such a stock measure is thus available in the

PSID for years 1981 to 2003. Mean health stock is 73.3 at age 26 while it falls to 39.7 by age 85. We define the same index in the MEPS since we use the MEPS to estimate the health shock process.

Health Shock The PSID has measures of health shocks starting in 1999. Only three waves are available. Hence, we use the MEPS for to estimate such process. From the MEPS, we define the incidence of a health shock as the incidence of either cancer, heart disease, lung disease, stroke, diabetes or hypertension. We estimate a logit model which depends on age and the health stock. Estimates are given below with standard errors in parenthesis.

$$\widehat{P}(\varepsilon_{a+1} = 1 \mid age, H_a) = \mathbf{\Lambda}(\underset{(0.3594)}{-6.206} + \underset{(0.0128)}{0.089}\, age - \underset{(0.0001)}{0.0005} age^2 - \underset{(0.023)}{0.09} \log(H_a))$$

We set the value of λ to 10.

Earnings We estimate the earnings profile from the PSID controling for fixed effects. Upon estimation, we use the average of the fixed effects for the 1936-1940 cohort to trace out the earnings profile. Estimates are reported below.

$$\widehat{\log(w_a)} = \underset{(0.226)}{0.938} + \underset{(0.009)}{0.097} age - \underset{(0.0001)}{0.001}\, age^2 + \underset{(0.0323)}{0.146} \log(H_a)$$

We estimate transition probabilities for unemployment using the PSID. Such estimates are available upon request.

Retirement Since our model considers a simplified definition of retirement, we use self-reports of respondents on whether they are fully or partially retired. We exclude as retired those who report being retired but are still at work. We use the retirement ages from the cohort born between 1931 and 1941 which has almost entirely retired by 2003.

Medical Consumption We use total and out-of-pocket medical expenditures from the Medical Expenditure Panel Survey (MEPS). We use data from 2000 to 2003 and express all amounts in 2004 dollars. We use a standardized employer provided health insurance contract. We use data reported in Blau and Gilleskie

(2004, Table 6) from the HHIPS supplement to the Health and Retirement Study which collects information from employers on insurance plans held by HRS respondents. First, we set the employee's premium equal to the median observed in HRS, \$480. We use the median maximum deductible for all services of \$200 and a co-insurance rate of 20%. Establishing a overall co-insurance rate and deductible for Medicare is more complicated. Only Medicare Part B has a common deductible-coinsurance structure. The premium is \$492 (\$41 per month), the deductible \$100 and the co-insurance rate 20%. Since the premium and co-insurance rate is roughly similar to that under the average employer provided plan, we set both plans to the same premiums (\$500), deductibles (200\$) and co-insurance rate (20%). For those who retire prior to being Medicare eligible, we assume they have access to retiree health insurance (they keep their employer coverage). In the 1931-1941 HRS cohort, 2/3 of respondents worked in firms where retiree health insurance was available.

AIME and Benefit Computation We consider a simplified version of the complex Social Security rules. Social Security benefits are basically a function of three factors: a measure of average earnings ($AIME$), birth year, and age at which benefits are first drawn. For our purposes, the Social Security earnings test is irrelevant since we assume individuals withdraw from the labor force at the time where they claim benefits. Furthermore, we model spouse benefits through other income such that the other's spouse's behavior is irrelevant.

The $AIME$ formally consists of the average of the highest 35 years of earnings. These earnings are indexed using the National Wage index upon age 60. We follow Rust, Buchinsky and Benitez-Silva (2001) and estimate a smooth function of next period's $AIME$ as a function of current $AIME$, earnings and age. We run age-specific regressions of the form

$$\log AIME_a = \varsigma_{0a} + \varsigma_{1a} I(w_a > 0) + \varsigma_{2a} \log w_a + \varsigma_{3a} \log AIME_{a-1} + \upsilon_a$$

where υ_a is an error term. We use earnings histories from HRS respondents to estimate parameters of that function.[5]

[5] These parameter estimates are available from the authors upon request.

To calculate the monthly benefit, the $AIME$ is transformed into the Primary Insurance Amount (PIA). The PIA is a piece-wise linear concave function of the $AIME$. The PIA is the benefit that would be paid if claimed at normal retirement age NRA. If the individual claims prior to the NRA, the PIA is reduced by 7.6%. For example, an individual born in 1931 who claims at age 62 will get 80% of his PIA. Similarly, an individual can claim his benefit past the NRA in which case a delayed retirement credit (DRC) is granted. The credit ranges from 3% to 8% depending on the age cohort. We use the DRC for those reaching 65 in 1998, 5.5%. Upon reaching 70, there is no DRC applied. Hence, we assume individuals claim Social Security benefits upon reaching 70 if they have not done it yet.

Initial Conditions We draw initial conditions for assets, aime and health based on estimate of a multivariate model of these outcomes at age 25. Since assets and health at age 25 are measured in the PSID while the AIME is measured in the HRS, we cannot directly estimate such correlations without additional assumptions. We substitute earnings for AIME when computing correlations. This is likely a good assumption at age 25 since little earnings history has built up. The correlation matrix between health, AIME and assets is given in the next table:

Table 1 Correlations in Initial Conditions

Correlations	Assets	Health	AIME
Assets	.	.	.
Health	0.005	.	.
AIME	0.222	-0.129	.

The correlation between health and assets is very weak at age 25 while the correlation between earnings and health is much stronger. AIME and assets are more strongly correlated.

4.1 Calibration of Structural Parameters

The following parameters need to be calibrated

$$\theta = (\gamma_c, \psi_a, \sigma, \phi_b, K, \theta_1, \theta_2, \theta_3, \beta, \delta_1, \delta_2)$$

No prior estimates of these parameters are available. We "choose" parameter values informally so as to match key statistics from the data such as median assets, medical expenditures and retirement ages. Hence, we make no claim on identification and it is perfectly possible that another combination of values would match equally well the data. Although this model has not been estimated previously, other studies are useful in fixing some of the parameters.

We focus on the investment model as very little guidance is given on how to calibrate γ_c. Hence, we set $\gamma_c = 1$ such that health does not enter the utility function. We choose a value of $\sigma = 0.75$ which is in the range considered by Picone et al. (1998) [0.6 to 0.9]. We set the parameters of the marginal utility of leisure so as to match the average retirement age in the data. We assume $\psi_a = \exp(\psi_0 + \psi_1(age - 55))$ with $\psi_0 = -0.25$ and $\psi_1 = 0.1$. We use the same parameter values as French (2005) for the bequest function. We set $\theta_b = 1.56$ and $K = 500$. As for health production, we select very similar parameters to Picone et al. (1998). We set $(\theta_1, \theta_2, \theta_3) = (\log(0.5), 0.25, 0.75)$ to fit the observed medical consumption profile. This implies more modest concavity than what Picone et al. (1998) assumed. We set $\delta_1 = 0.035$ and $\delta_2 = 0.025$ so that depreciation is 3.5% at age 25 and increases thereafter. Finally, we assume individuals have a discount factor equal to 0.985 to match as close as possible the asset profile. The real interest rate is set to 3% so that there is a mild savings motive in the model ($1/1.03<\beta$).

5 Fit

In Figure 1, we present average simulated non-medical and medical consumption profiles. In the first graph, we replicate the hump-shape pattern of consumption over the life-cycle. Consumption tracks income relatively closely. The bottom graph shows the simulated medical consumption profile along with the same profile as estimated on MEPS data. The fit in the mid-age range is quite remarkable. However, it appears that the calibration used leads to lower simulated medical consumption at younger ages and much higher expenditures at older ages. The general upward pattern over the life-cycle is generally well-captured in the simulated data. The health stock decreases over the life-cycle, starting from a mean of 75 and falling to 20 around the age of 80.

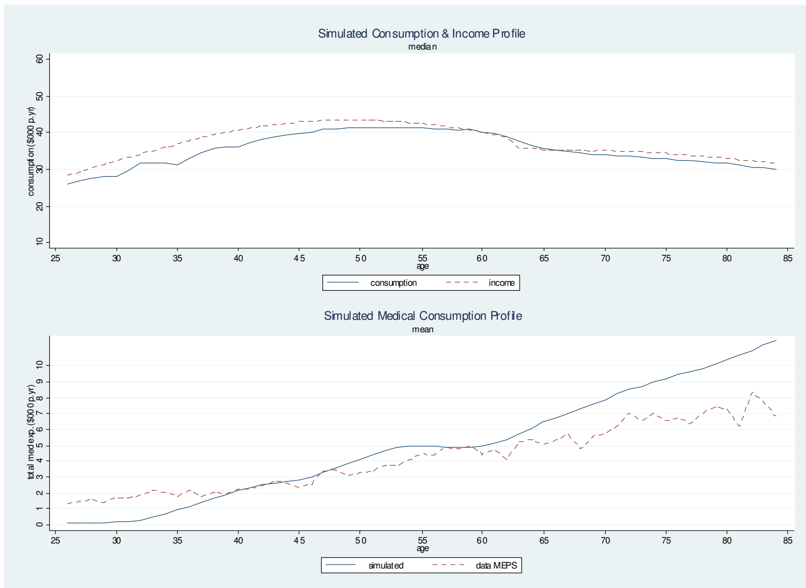

Figure 1: Simulated Consumption Profiles

In Figure 2, we present the simulated median asset profile along with the same profile from the PSID. The model tracks assets quite well until retirement. However, it tends to imply stronger dissaving at older ages than observed in the data. There are several potential reasons for this result. First, although the model allows for mortality, few agents die in the simulation. This is because they maintain their health stock always slightly above 10 (the size of the health shock). Since medical consumption is relatively productive and they have accumulated enough assets, they can always "repair" their body following a shock. A second explanation is that the bequest motive is not strong enough in the model. This could explain why individuals prefer to invest in health rather than in assets at older ages.

In the second graph, we present the simulated retirement hazard rates along with those from the PSID. We simulate that most individuals retire around the age of 63 and 65 with very few, mostly wealthier respondents retiring prior to

62. Because heterogeneity is limited in the model, we observe little variation in retirement ages. This could be solved by introducing earnings uncertainty or a heterogeneous taste for leisure.

Figure 2: Simulated Assets and Retirement Profiles

The informal calibration we used does a relatively good job of capturing stylized facts from the data. In particular, it captures the hump-shape profile of consumption, the increasing profile of medical consumption, asset accumulation and the average retirement age observed in the data. A natural next step would be to estimate formally the structural parameters of the model. We leave this for future research.

6 Simulations

6.1 Co-Pay Elasticity

We analyze the response to a permanent and anticipated change in the co-insurance rate from 20% to 100%. Hence, we analyze a parametric change from partial insurance to self-insurance. This increases the price of medical consumption. Individuals have to self-insure against medical expenditures. To highlight the effect of allowing for endogeneous retirement on such a response, we consider two cases: one where retirement is endogeneous, the other where retirement is fixed at age 63 (the modal age of retirement in the baseline simulation).

Two effects are to be expected when we remove partial insurance. First, there is a direct substitution effect through an increase in the user cost of health capital. Hence, less health should be demanded. The top graph in Figure 3 shows that medical consumption goes down over the entire life-cycle. In consequence, health capital also goes down. Since out-of-pocket risk goes up, individuals may save more to finance medical consumption. This is a form of self-insurance. The second graph in Figure 3 shows that individuals accumulate more assets early on to finance such gap. The total response of the demand for health can be mitigated because individuals decide to retire later in order to finance the increased life-time cost of maintaining health. Depending on the wage profile and the Social Security benefit formula, individuals can potentially increase life-time income by delaying retirement. The last graph in Figure 3 shows that indeed individuals delay retirement. The cumulative fraction of retired individuals at age 65 goes down by roughly 50%. On average, individuals are worse off under self-insurance.

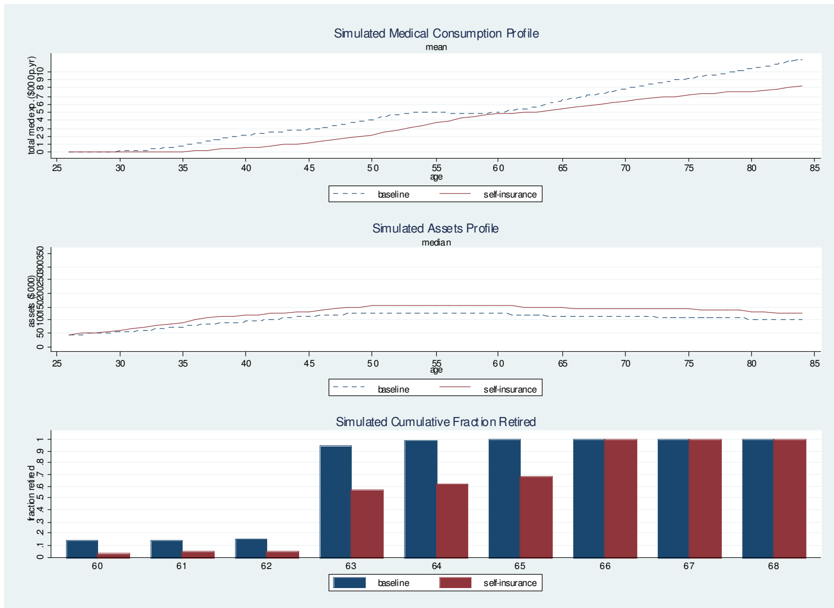

Figure 3: Simulated Response to a Change from Partial Insurance to Self-Insurance When Retirement is Endogeneous

To isolate the effect of endogeneous retirement on the price response, we now perform the same counterfactual (removing partial insurance). We also analyse a second scenario, we set retirement at 63 years old which is the modal age in the baseline. We resolve the model with this fixed retirement age and the counterfactual. We then compute medical consumption elasticities at each age using the formula

$$\eta_a = \frac{m_a^1 - m_a^0}{1 - \mu_2} \frac{\mu_2}{m_a^0} \tag{16}$$

where m_a^k denotes average medical consumption under scenario $k = 0$, the baseline with partial insurance, and 1 the counterfactual with self-insurance. The co-insurance rate μ_2 is 0.2 in the baseline while it is 1 in the counterfactual. The next table reports elasticity estimates in the case where retirement is endogeneous and when retirement is exogeneous.

Table 2 Price Elasticity Estimates by Age Group

	when retirement is	
age group	endogeneous	exogeneous
25 to 45	-0.206	-0.212
46 to 64	-0.069	-0.080
65 to 84	-0.056	-0.065
85+	-0.063	-0.072
Total	-0.106	-0.110

Looking first at elasticity estimates when retirement is endogeneous (first column), we get an average elasticity estimate of -0.106 which is in the lower end of the range of estimated price elasticities in the literature. For example, the Rand Health Insurance (RHI) experiment, which focused on the non-elderly population found elasticities in the range of -0.17 to -0.22 (Newhouse et al., 1993). However the RHI excluded the elderly. Focusing on the same population (younger than 60), we get an elasticity estimate of -0.152. Our implied elasticity are smaller at older ages. In the model, the type of care received by in old age is curative rather than preventive (in response to a health shock). Hence, it is likely less substituable and therefore less elastic. Also since preventive care involves benefits that may arise long into the future, it might be more sensitive to price changes. Very few studies exist estimating the price elasticity of the demand for care among the elderly. However, a common finding in the literature is that acute care tends to be less price sensitive than preventive care (Ringel et al., 2002). Near retirement, we also find that the elasticity tends to be smaller. This may be due to the fact that individuals near retirement have a strong incentive to invest in health since their earnings might increase future pension benefits. Hence, they are less elastic to price changes.

Making retirement exogeneous amplifies price responses as can be seen the second column of Table 2. This is because there is no margin of adjustment to respond to the income effect induced by an increase in life-time medical expenditures for a given health level. Hence, medical expenditures falls more. The average elasticity is -0.11 which is 1% higher than when retirement is endogeneous. Hence, the income effect is relatively small. This is likely dependent on the calibration we used, in particular for the marginal utility of leisure. In terms of lifetime medical consumption, medical consumption goes down by \$10,400 more when retirement is exogeneous which represents 2.3% of life-time medical expenditures.

7 Conclusions

In this paper, we extend the health production model due to Grossman (1972) in two directions. First, we introduce retirement and a relatively realistic Social Security system. Second, we allow for both unemployment risk and health shock risk simultaneously where unemployment risk is tied to the availability of health insurance prior to Medicare eligibility. We calibrate the model using data from the U.S. on asset accumulation, medical expenditures and retirement. Upon calibration of the model, we find plausible price elasticies of the demand for health which are in the range of estimated elasticities in the literature. The model also yields that health expenditures are more elastic at younger ages than at older ages and that individuals self-insure against health risks by accumulating more assets. We also find that the price elasticity of the demand for health depends in part on whether endogeneous retirement is possible.

The model could be extended in a number of dimensions. First, allowing for more heterogeneity in terms of earnings and preferences would allow to capture better the heterogeneity in behavior which is observed in the data. Second, our simulations reveal quite low levels of mortality, far below what is observed from life-tables, and our asset and medical expenditure profiles deviate substancially from those observed in the data in old age. Hence, a more formal form of calibration, for example the method of simulated moments, would be beneficial to attempt to improve on the fit of the model. In turn, this implies that we should devote more attention to the identification of structural parameters from moments in the data. Third, estimation of the earnings and health shock profiles relied on a simplified health index constructed from the data. In principle, the parameters of these profiles could be estimated jointly with other structural parameters.

8 References

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