Online Appendices for Finkelstein, Luttmer and Notowidigdo
"What Good is Wealth Without Health? The Effect of Health on the Marginal Utility of Consumption"

Online Appendix A: Derivations and Extensions of the Theoretical Model

Determination of optimal savings

We now prove the claim from Section 2.1 that individuals' second-period wealth is proportional to their lifetime income and we determine the proportionality factor *w*. We first calculate expected second-period utility as a function of second-period wealth by taking the weighted average of equations (4) and (8), where the weights are the 1-*p* and *p* respectively. This yields:

$$E_1\left[U_2\right] = \left(\frac{(1-p)}{1-\gamma} + p\left(\frac{1+\varphi_1}{1-\gamma}\left(1+\varphi_2^{1/\gamma}(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\right)^{\gamma}\right)\right)W^{1-\gamma} = kW^{1-\gamma}\,, \tag{A.1}$$

where the constant *k* is defined by:

$$k \equiv \frac{(1-p)}{1-\gamma} + p\left(\frac{1+\varphi_1}{1-\gamma}\left(1+\varphi_2^{1/\gamma}(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\right)^{\gamma}\right). \tag{A.2}$$

We use the intertemporal budget constraint $W = (1+r)(Y(1-\tau) - C_1)$ to express expected second-period utility as a function of first-period consumption:

$$E_1\left[U_2\right] = kW^{1-\gamma} = k\left((1+r)\left(Y(1-\tau)-C_1\right)\right)^{1-\gamma}. \tag{A.3}$$

Substituting equation (A.3) into the lifetime utility function (1) yields:

$$U = \left(\tfrac{1}{1-\gamma}\right)\left(C_1^{1-\theta} + \tfrac{1}{1+\delta}\left((1-\gamma)k\right)^{(1-\theta)/(1-\gamma)}\left((1+r)\left(Y(1-\tau)-C_1\right)\right)^{(1-\theta)}\right)^{(1-\gamma)/(1-\theta)} \tag{A.4}$$

We now have expressed lifetime utility as a function of a single choice parameter, C_1. Setting the derivative of (A.4) with respect to C_1 to zero yields:

$$C_1 = \frac{\left((1-\gamma)k\right)^{(\theta-1)/\theta(1-\gamma)}(1-\tau)}{\left((1-\gamma)k\right)^{(\theta-1)/\theta(1-\gamma)} + (1+\delta)^{\theta}(1+r)^{-\theta-1}} \times Y \equiv c_1 Y\,, \tag{A.5}$$

where the constant c_1 is defined by:

$$c_1 \equiv \frac{\left((1-\gamma)k\right)^{(\theta-1)/\theta(1-\gamma)}(1-\tau)}{\left((1-\gamma)k\right)^{(\theta-1)/\theta(1-\gamma)} + (1+\delta)^{\theta}(1+r)^{-\theta-1}}. \tag{A.6}$$

Equation (A.5) establishes that first-period consumption is proportional to lifetime income Y. Substituting (A.5) into the intertemporal budget constraint demonstrates second-period wealth must therefore also be proportional to lifetime income:

$$W = (1+r)\big(Y(1-\tau) - C_1\big) = (1+r)\big(Y(1-\tau) - c_1 Y\big) = (1+r)\big(1-\tau-c_1\big)Y \equiv wY\ , \tag{A.7}$$

where the constant of proportionality w is defined by:

$$w = (1+r)\big(1-\tau-c_1\big)\,. \tag{A.8}$$

Generalization of the model for a free choice of the health services elasticity

In Section 2.1, we chose the functional form for the health subutility function $\Psi(H)$ to be a power function with exponent 1-γ. This choice of functional form substantially simplified the exposition, but restricted ε, the substitution elasticity of consumption and health services, to be equal to minus the inverse of the coefficient of relative risk aversion. We now demonstrate that allowing for an arbitrary, but constant, substitution elasticity of consumption and health services yields an estimating equation for state dependence that is identical to equation (14) derived in Section 2.1. In other words, our estimates of state dependence do not depend on the value of the substitution elasticity of consumption and health services. The intuition behind this result is that our estimating strategy does not rely on variation in the relative price of consumption and health services, and therefore does not depend on the elasticity of consumption choices with respect to this relative price. The substitution elasticity of consumption and health services is of course important in our simulations of the effect of state dependence on optimal insurance. In those simulations, we use the more general model described below. Note that all equations below reduce to the equations described in Section 2.1 when $\varepsilon = -1/\gamma$.

We generalize the second-period subutility function by replacing the power functional form of equation (2) by a CES functional form:

$$U_2 = \left(\tfrac{1}{1-\gamma}\right)(1+\tilde{\varphi}_1 S)\left[C_2^{1+1/\varepsilon} + \tilde{\varphi}_2 S H^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}\right)}. \tag{A.9}$$

In the CES formulation, the degree of state dependence in the marginal utility of consumption (evaluated at a constant level of consumption) depends on the level of health services consumed. Hence, state dependence, φ_1, is a function both of the dependence of the utility function on health, as measured by the parameter $\tilde{\varphi}_1$, and of the relative price of health services. We derive the relationship between φ_1 and $\tilde{\varphi}_1$ by first calculating the marginal utility of consumption in the healthy and in the sick state:

$$dU_{2,S=0} / dC_2 = C_2^{-\gamma} \quad \text{and} \tag{A.10}$$

$$dU_{2,S=1} / dC_2 = (1+\tilde{\varphi}_1)\left[C_2^{1+1/\varepsilon} + \tilde{\varphi}_2 H^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}-1\right)} C_2^{1/\varepsilon}\,. \tag{A.11}$$

Taking the ratio of (A.11) to (A.10) and simplifying yields:

$$(1+\varphi_1) \equiv \frac{dU_{2,S=1} / dC_2}{dU_{2,S=0} / dC_2} = (1+\tilde{\varphi}_1)\left[1+\tilde{\varphi}_2\left(H / C_2\right)^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}-1\right)}. \tag{A.12}$$

In the CES formulation for the utility function, the marginal utility of health services depends not only on the level of health services but also on the state dependence parameter and non-health consumption:

$$dU_{2,S=1} / dH = (1+\tilde{\varphi}_1)\tilde{\varphi}_2\left[C_2^{1+1/\varepsilon}+\tilde{\varphi}_2 H^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}-1\right)} H^{1/\varepsilon} \tag{A.13}$$

For consistency with the power utility formulation, we define φ_2 as the marginal utility of health scaled by $H^{1/\varepsilon}$:

$$\varphi_2 \equiv \frac{dU_{2,S=1} / dH}{H^{1/\varepsilon}} = (1+\tilde{\varphi}_1)\tilde{\varphi}_2\left[C_2^{1+1/\varepsilon}+\tilde{\varphi}_2 H^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}-1\right)} \tag{A.14}$$

When we vary φ_1 in our simulations (see online Appendix C), we hold φ_2 constant at the initial levels of C_2 and H. We use equations (A.12) and (A.14) to solve for the values for $\tilde{\varphi}_1$ and $\tilde{\varphi}_2$ such that φ_2 remains constant and φ_1 varies as desired.

To derive our estimating equation, we follow the same strategy as in Section 2.1. We start by solving for the optimal consumption choices in period 2 given second-period wealth W:

$$\underset{C_2,H}{\text{Max}}\, U_2(C_2,H) = \underset{C_2,H}{\text{Max}}\left(\tfrac{1}{1-\gamma}\right)(1+\tilde{\varphi}_1 S)\left[C_2^{1+1/\varepsilon}+\tilde{\varphi}_2 S H^{1+1/\varepsilon}\right]^{\left(\frac{1-\gamma}{1+1/\varepsilon}\right)} \tag{A.15}$$

$$\text{s.t. } C_2+(1-b)H = W$$

Conditional on being sick, the resulting optimal consumption and health services are given by:

$$C_2 = \frac{W}{1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}} \text{ and} \tag{A.16}$$

$$H = \frac{(1-b)^{\varepsilon}\tilde{\varphi}_2^{-\varepsilon} W}{1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}}. \tag{A.17}$$

Substituting (A.16) and (A.17) into the second-period utility function yields second-period utility as a function of second-period wealth for sick individuals (S=1):

$$U_2 = \left(\tfrac{1}{1-\gamma}\right)(1+\tilde{\varphi}_1)\left(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\right)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)} W^{1-\gamma}. \tag{A.18}$$

Second-period utility for healthy individuals (S=0) is:

$$U_2 = \left(\tfrac{1}{1-\gamma}\right) W^{1-\gamma} \tag{A.19}$$

We calculate expected second-period utility as the weighted average of equations (A.18) and (A.19). So expected utility is:

$$E_1\left[U_2\right] = \left(\frac{(1-p)}{1-\gamma} + p\left(\frac{1+\tilde{\varphi}_1}{1-\gamma} \left(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\right)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)} \right)\right) W^{1-\gamma} = \tilde{k} W^{1-\gamma} \tag{A.20}$$

where the constant $\tilde{k}$ is defined by:

$$\tilde{k} \equiv \frac{(1-p)}{1-\gamma} + p\left(\frac{1+\tilde{\varphi}_1}{1-\gamma} \left(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\right)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)} \right). \tag{A.21}$$

We use the intertemporal budget constraint $W = (1+r)(Y(1-\tau) - C_1)$ to express expected second-period utility as a function of first-period consumption:

$$E_1\left[U_2\right] = \tilde{k} W^{1-\gamma} = \tilde{k}\left((1+r)\left(Y(1-\tau)-C_1\right)\right)^{1-\gamma}. \tag{A.22}$$

Substituting equation (A.22) into the lifetime utility function (1) yields:

$$U = \left(\tfrac{1}{1-\gamma}\right)\left(C_1^{1-\theta} + \tfrac{1}{1+\delta}\left((1-\gamma)\tilde{k}\right)^{(1-\theta)/(1-\gamma)} \left((1+r)\left(Y(1-\tau)-C_1\right)\right)^{(1-\theta)} \right)^{(1-\gamma)/(1-\theta)} \tag{A.23}$$

We now have expressed lifetime utility as a function of a single choice parameter, C_1. Setting the derivative of (A.23) with respect to C_1 to zero yields:

$$C_1 = \frac{\left((1-\gamma)\tilde{k}\right)^{(\theta-1)/\theta(1-\gamma)}(1-\tau)}{\left((1-\gamma)\tilde{k}\right)^{(\theta-1)/\theta(1-\gamma)} + (1+\delta)^{\theta}(1+r)^{-\theta-1}} \times Y \equiv (1-s^*)(1-\tau)Y \equiv \tilde{c}_1 Y\ , \tag{A.24}$$

where s^* denotes the optimal savings rate and where the constant $\tilde{c}_1$ is defined by:

$$\tilde{c}_1 \equiv \frac{\left((1-\gamma)\tilde{k}\right)^{(\theta-1)/\theta(1-\gamma)}(1-\tau)}{\left((1-\gamma)\tilde{k}\right)^{(\theta-1)/\theta(1-\gamma)} + (1+\delta)^{\theta}(1+r)^{-\theta-1}}. \tag{A.25}$$

Equation (A.24) establishes that first-period consumption is proportional to lifetime income Y. Substituting (A.24) into the intertemporal budget constraint demonstrates second-period wealth must therefore also be proportional to lifetime income:

$$W = (1+r)\big(Y(1-\tau) - C_1\big) = (1+r)\big(Y(1-\tau) - \tilde{c}_1 Y\big) = (1+r)\big(1-\tau-\tilde{c}_1\big)Y \equiv \tilde{w}Y \,, \tag{A.26}$$

where the constant of proportionality $\tilde{w}$ is defined by:

$$\tilde{w} = (1+r)\big(1-\tau-\tilde{c}_1\big) \,. \tag{A.27}$$

Substituting $W = \tilde{w}Y$ into equations (A.18) and (A.19), yields indirect utility, $v(Y,S)$, in the second period for the healthy state and the sick state, respectively:

$$v(Y,0) = \frac{1}{1-\gamma}(\tilde{w}Y)^{1-\gamma} \text{, and} \tag{A.28}$$

$$v(Y,1) = \frac{1}{1-\gamma}(1+\tilde{\varphi}_1)\big(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\big)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)}\big(\tilde{w}Y\big)^{1-\gamma} \,. \tag{A.29}$$

These indirect utility functions suggest a nonlinear regression of the following form:

$$v = \beta_1 S \times Y^{\beta_2} + \beta_3 Y^{\beta_2} + \varepsilon \,, \tag{A.30}$$

which yields the parameter estimates:

$$\beta_1 = (1+\tilde{\varphi}_1)\big(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\big)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)}\frac{\tilde{w}^{1-\gamma}}{1-\gamma} - \frac{\tilde{w}^{1-\gamma}}{1-\gamma}, \quad \beta_2 = 1-\gamma \,, \quad \text{and } \beta_3 = \frac{\tilde{w}^{1-\gamma}}{1-\gamma} \,. \tag{A.31}$$

Taking the ratio of the incremental income gradient of utility in the sick state (β_1) to the income gradient in the healthy state (β_3) yields:

$$\beta_1 / \beta_3 = (1+\tilde{\varphi}_1)\big(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\big)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)} - 1 \,. \tag{A.32}$$

Using equation (A.12) to replace $\tilde{\varphi}_1$ by φ_1 yields:

$$\beta_1 / \beta_3 = (1+\varphi_1)\Big[1+\tilde{\varphi}_2\big(H / C_2\big)^{1+1/\varepsilon}\Big]^{\left(1-\frac{1-\gamma}{1+1/\varepsilon}\right)}\big(1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\big)^{\left(\frac{\gamma-1}{1+\varepsilon}\right)} - 1 \,. \tag{A.33}$$

Taking the ratio of equations (A.17) to (A.16) shows that $m \equiv H / C_2 = (1-b)^{\varepsilon}\tilde{\varphi}_2^{-\varepsilon}$. Substituting this expression into equation (A.33) and simplifying yields:

$$\beta_1 / \beta_3 = (1+\varphi_1)\big[1+(1-b)^{\varepsilon+1}\tilde{\varphi}_2^{-\varepsilon}\big]^{\gamma} - 1 = (1+\varphi_1)\big[1+m(1-b)\big]^{\gamma} - 1 \,. \tag{A.34}$$

This equation is identical to equation (14) in Section 2.1. Hence, the inference of state dependence φ_1 from the parameter ratio β_1/β_3 is the same regardless of the elasticity of substitution between consumption and health services.

Online Appendix B: Data Appendix

I. Health and Retirement Study

Our analysis uses data from all cohorts (and their spouses) in the first seven waves of the HRS. The original HRS cohort is surveyed in every even year starting in 1992. The AHEAD cohort is surveyed in 1993, 1995, 1996, 1998, 2000, 2002 and 2004. The War Baby and CODA cohorts are surveyed in 1998, 2000, 2002 and 2004. For more detail on the data and the sample see http://hrsonline.isr.umich.edu/intro/index.html**.** We use the RAND HRS data set, which is a "cleaned, easy-to-use, streamlined version" (http://hrsoline.isr.umich.edu/meta/r/and/), and merge in some additional variables that are needed.

Sample selection:

- Aged 50 and older. This restriction is only binding for spouses, since the HRS only sampled main respondents age 50 and older.
- Not in labor force. We define individuals as not in the labor force if they (1) self-report that they are either retired or that the retirement question is "not applicable" (presumably reflecting no serious prior labor market attachment) and (2) have annual earnings of less than $5,000. Since the retirement question is not asked in the 1994/1995 waves, we include individuals in this wave if they meet the criteria in the prior wave.
- Have health insurance. We define an individual as having health insurance if she is covered by any private or public insurance.
- We require that the individual maintains her retirement status and insurance coverage while she is in the sample. Individuals who do not initially meet these criteria can enter our sample in subsequent waves if they subsequently meet the criteria, but we drop all spells in the sample that do not terminate with the last observation of the individual meeting the sample selection criteria.[1]
- We exclude the bottom percentile of the permanent income (defined below) distribution from our analysis, given the potential sensitivity of the coefficient on the log of permanent income (which we use in our baseline specification) to such outliers. In practice, including these individuals does not have a substantive effect on the results.
- Finally, we require that the individual appear in the baseline sample for more than one wave, and only use person-years where the key variables have non-missing values.

Variable definitions

- *Annual household income (adjusted for household composition)*: Total annual household income is the sum of household income from wages and salaries, capital income (business income, dividend and interest income, and other asset income), pensions, government transfers, and other sources. We also add 5% of the household's current financial wealth (that is, total household wealth not including housing or automobile) to this aggregate household income measure to account for the fact that elderly households may be spending down their accumulated financial savings; results are unaffected if we instead assume a 10% or 0% "drawdown" rate of financial wealth. We use the OECD

---

[1] As a specification check, we also define a sample where once an individual enters the sample, the individual remains in the sample indefinitely regardless of changes to health insurance and retirement status, and the results are extremely similar. As an additional specification check, we applied the sample criteria on a year-by-year basis, and again find very similar results.

adjustment for household size (Atkinson et al. 1995), dividing total household income by 1.7 if the respondent is married and living with a spouse in the same household in that wave.

- *Permanent income*: Average across all waves of annual household income (adjusted for household composition in the same manner)
- *Measures of chronic disease*: The exact question is "Has a doctor ever told you that you had X." These variables have been coded in the RAND data set to be absorbing states.
- *Wealth measure* (used in Appendix Table A12 column 3 as an alternative measure of permanent income): The wealth measure used is constructed by averaging household wealth across all waves in which a household appears. The measure of wealth we use excludes net housing wealth and automobile wealth. It includes the sum of the net value of financial wealth (e.g., stocks, mutual funds, investment trusts, checking, savings, money markets, CD's, T-bills) and other savings and assets minus non-housing and non-automobile debts. We limit the sample to households with more than $1,000 in wealth, which results in a roughly 20% reduction in sample size from the baseline sample.

Consumption and Activities Mail Survey (CAMS)

The Consumption and Activities Mail Survey (CAMS), a small topical module administered to about 30% of households in the HRS for three waves, allows us to construct a broad-based measure of total consumption as well as non-durable consumption. These consumption measures include out-of-pocket medical expenditures, so they can be considered proxies for second-period wealth. The CAMS survey was mailed to 5,000 households selected at random from the 13,214 households in HRS 2000; they received 3,866 respondents in 2001 and followed up with the respondent sample in 2003 and 2005 to form a household-level panel data set on consumption. We use all three waves of CAMS, matching each to the preceding HRS survey years since the CAMS asks about consumption in the previous year. The survey asks about 6 "big-ticket" durable consumption items and 26 non-durable consumption categories that are modeled after the Consumer Expenditure Survey (CEX) and designed to encompass the exhaustive set of non-durable consumption categories in the CEX. We follow Hurd and Rohwedder (2005) to construct measures of total consumption and total non-durable consumption; they also provide more detail on the survey and the underlying data.

Whenever specifications using CAMS data include household fixed effects, we create a new household fixed effect any time the household composition changes (either through changes in household size or changes in identity of respondent's spouse).

II. Medical Expenditure Panel Survey (MEPS)

The Medical Expenditure Panel Survey allows us to compute the out-of-pocket health expenditure as a share of non-health consumption, $m(1\text{-}b)$, for the various samples used in Table 3. In all computations, we use total out-of-pocket health expenditures, as reported by the individual. This measure includes all health expenditures for office- and hospital-based care, home health care, dental services, vision services, and prescribed medicine. We use data from the 1996 MEPS limited to individuals who meet the same sample selection criteria as we applied to our HRS sample. As with the HRS above, our baseline sample selection criteria are the following: individuals who are age 50 and older, are not in the labor force (either retired or non-working), and have health insurance. We use this sample to compute the difference in mean out-of-pocket health spending for those whose medical spending is above the median and those whose medical spending is below the median. We scale this difference by the mean annual consumption, determined using the HRS CAMS survey (described above). Alternative sample selection criteria are described in Table 3, and we follow these same criteria in the MEPS when computing the out-of-pocket health expenditure share for each sample. Sample sizes for the three samples are 2,556, 1,898 and 488, respectively.

III. British Household Panel Survey (BHPS)

The British Household Panel Survey (BHPS) is an annual longitudinal survey covering "labor markets outcomes, income, savings and wealth, household organization, housing, consumption, social and political values, education, and training."[2] The original sample contained about 5,500 households and about 10,000 individuals. Initially, the response rate was very high (>95%), but by year 2000 there was moderate attrition (65% of wave 1 respondents who were still alive and in United Kingdom in 2000 gave an interview in 2000, and 55% of respondents gave responses in all waves).

We use the 14 waves between 1990 and 2003, and we impose baseline sample restrictions similar to those that we used with the HRS sample. In particular, just as in the HRS, we limit the BHPS sample to age greater than 50 who are not in the labor force and are covered by health insurance.

The proxy for utility that we use in the BHPS is the answer to the following question: "How dissatisfied or satisfied are you with your life overall?" Individuals respond on a 7-point scale where 1 corresponds to "not satisfied at all" and 7 corresponds to "completely satisfied" (intermediate values are not explicitly defined). This 7-point scale may capture movements in subjective well-being better than our binary happiness measure in the HRS. A possible drawback of the BHPS measure, however, is that it asks about a global evaluation of one's life, which may be a harder question to answer than one's current feeling of happiness (and, therefore, perhaps more prone to judgment biases). Further, a global evaluation of happiness may be affected by past or future well-being rather than just current well-being. A more general drawback to using the BHPS data set is the considerably smaller sample size of individuals who meet the baseline sample restrictions (only about 4,500 individuals and 20,000 observations in the BHPS versus roughly 11,500 individuals and 45,000 observations in the HRS).

As with the HRS data set, we compute household permanent income by taking an average of total household income (including pension payments, annuity payments, disability payments, government transfers and other government allowances) across all waves. The primary health measure that we use in the BHPS sample is the individual's total number of reported diseases, using the diseases that appear consistently in all waves (excluding depression, alcohol use, drug use, and epilepsy): problems with arms/legs/hands, difficulty hearing, difficulty seeing, skin problems, chest/breathing problems, heart problems and/or hypertension, stomach/digestion problems, diabetes, migraines, and other diseases.[3] Note that this set of diseases is somewhat different from the HRS set (see Appendix Table A1 for a description of diseases used to construct the HRS health measure).

[2] The BHPS is described in more detail here: http://www.iser.essex.ac.uk/ulsc/bhps/quality-profiles/BHPS-QP-01-03-06-v2.pdf

[3] Cancer and Stroke (which are diseases that also appear in HRS) appear only in the last 3 waves.

Online Appendix C: Details of the Calibrations

The model in the main text imposes that the elasticity of substitution between health services consumption and non-health consumption (ε) and the coefficient of relative risk aversion (γ) are related through $\varepsilon = -1/\gamma$. While this restriction simplifies the exposition and is inconsequential for our empirical estimating equation, we do not want to impose this restriction in our calibration exercises. For the calibrations, we therefore use the generalized model from Appendix A (equations A.9 onwards). The optimal savings rate, s^*, is a direct outcome of this model (see equation A.24), and we define the optimal level of health insurance b^* as the level of b that maximizes lifetime utility (from equation 1) if individuals treat b and τ as given and the tax rate τ is set to satisfy the government budget constraint in expectation.[4] To implement the calibration, we choose parameter values based on the empirical literature, as described below. We use the same parameter values for the savings calibration as for the optimal insurance calibration.

There are two sources of uncertainty which affect expected utility in period 2: (i) uncertainty about future health status (i.e., agent enters sick state with probability p) and (ii) uncertainty about the rate of return on savings (r). We choose a probability of the sick state (p) of 0.5 so that our measure of the sick state is whether or not an individual has below-median health. To compute the distribution of returns on savings, we use the following procedure. First, we compute real annual returns on the S&P 500 between 1889 and 2008 using data from Shiller (1989)[5]. Next, we create 1000 counterfactual 25-year returns by sampling these annual returns with replacement. We assume that the return on savings is statistically independent of the random variable governing the consumer's future health status, and we use these two sources of uncertainty to compute expected utility in period 2 given the consumer's choice of savings in period 1.

We choose $\varepsilon = -0.20$, which matches the empirical estimates from the RAND Health Insurance Experiment (Manning et al., 1987). We parameterize the two-period model so that the periods are 25 years apart. We use an annual discount rate of 2.7% (Barro, 2009), which gives $\delta = (1.027)^{25} - 1$. We choose this value of δ for our baseline value of risk aversion and for a value of θ such that we have an expected utility function ($\gamma = \theta = 3$). For other values of γ and θ, we choose δ so that the optimal savings rate (s^*) with no state dependence ($\varphi_1 = 0$) is the same across all values of γ and θ. This ensures that the *effective* rate of time preference is the same in all simulations (Barro, 2009).

For each combination of γ and θ, we calibrate φ_2, the parameter that governs the level of demand for health services, such that the ratio of health services consumption to non-medical consumption matches the empirically observed ratio m of 0.236 at the empirically observed level of insurance b of 0.851 when $\varphi_1 = 0$.[6] We keep φ_2 constant at this level as we vary φ_1 and allow

[4] The expectation is over the probability of falling sick and over the real interest rate realization. Numerically, we implement this by starting with $\tau = 0$, and iteratively choosing taxes such that in expectation the government budget is balanced (given candidate optimal savings level).

[5] We use the updated data that Shiller has posted on his website: http://www.econ.yale.edu/~shiller/data.htm.

[6] We compute b, the average degree of insurance coverage, using the 1996 Medical Expenditure Panel Survey (MEPS) data set, imposing the same sample restrictions as in the HRS sample. For these individuals, we compute average share of out-of-pocket health expenditures as a fraction of total health expenditures, and subtract this share from one to obtain b. We compute m ($=H/C_2$) based on data on the distribution of health spending and the distribution of annual household consumption. Since H is the incremental health spending associated with becoming sick, we approximate it using data from the 1996 MEPS based on the difference in mean medical spending for those whose medical spending is above the median ($10,194) and those whose medical spending is below the median

m and b^* to be determined endogenously.

As we noted in Appendix A (between equations A.9 and A14), state dependence φ_1 in the generalized model depends not only on primitive parameters of the generalized model ($\tilde{\varphi}_1$, $\tilde{\varphi}_2$, ε, and γ) but also on the endogenous ratio of health to non-health consumption. Similarly, the valuation of health services φ_2 depends not only on primitive parameters of the generalized model ($\tilde{\varphi}_1$, $\tilde{\varphi}_2$, ε, and γ) but also on the levels of health services consumption and non-medical consumption. For each combination of γ and θ, we set $\tilde{\varphi}_1$ and $\tilde{\varphi}_2$ such that φ_1 takes on its desired value (0.0, –0.2, or –0.4) and φ_2 remains constant at the level described above for the baseline choices of health services consumption and non-medical consumption (see equations A.12 and A.14 in Appendix A for the system of equations which we jointly solve numerically; the baseline choices of health services consumption and non-medical consumption are defined by the empirically observed ratio m of 0.236 and the baseline savings rate at $\varphi_1=0$). Finally, in a non-expected utility framework, the savings rate also responds to the level of second-period utility (not just to marginal utility in the second period). To ensure that changes in φ_1 only affect savings behavior through its effect on marginal utility, we add a constant to equation A.9 in the sick state such that the level of second-period utility for our baseline ratio of health services consumption to non-medical consumption of 0.236 in the sick state remains constant within each combination of γ and θ as we vary φ_1.

In the savings calibrations presented in Table 8, we set the level of insurance b equal to its empirically observed level of 0.851 and solve for the optimal savings rate s^* as φ_1 takes on the values 0, –0.2, or –0.4. For the optimal insurance calibrations presented in Table 9, we solve the same model as in the savings calibrations but do this for the range of possible values of b. We report as the optimal insurance level b^* the value that maximizes lifetime utility. As before, the individual treats b and τ as exogenous, and τ is set such that the government budget constraint is satisfied in expectation.

($704). Using the consumption data in the CAMS survey (described in more detail in Appendix B), we find that mean annual consumption is $41,648. Consumption in the CAMS is calculated on a household basis, so we converted consumption to an individual-level measure using the OECD adjustment for household composition (see Appendix B for details). Dividing the difference in average health spending (between average spending for those above and below the median) by mean annual non-health consumption gives $m = 0.236$.

Online Appendix D: Semiparametric Estimator of the Mapping *g*(.)

We generalize the standard probit model by flexibly estimating a nonlinear, monotonic transfer function $h(v)$. In our application, this transfer function maps von Neumann-Morgenstern utility v to the latent variable in a probit model with a binary subjective well-being outcome variable, *HAPPY*:

$$HAPPY_i = \begin{cases} 1 & \text{if} \quad h(v_i) > \eta_i \\ 0 & \text{if} \quad h(v_i) \leq \eta_i \end{cases},$$

where η_i is a standard normal error term. The transfer function $h(v)$ is specified as a ninth-order polynomial that is constrained to be monotonically increasing using the rearrangement technique of Chernozhukov, Fernandez-Val, and Galichon (2009). Without loss of generality, we normalize $h(0)=0$ and $h'(0)=1$. We impose utility v to have the amount of curvature that corresponds to a coefficient of relative risk aversion of γ:

$$v_i = \pi_1 \frac{\bar{Y}_i^{1-\gamma}}{1-\gamma} + \pi_0 ,$$

where π_1 and π_0 are parameters to be estimated. The polynomial coefficients and π_1 and π_0 are estimated by maximizing the following log likelihood function:

$$\max_{h(.),\pi_0,\pi_1} \sum_{i,t} \left(HAPPY_{it} \times \log(\Phi(h\left(\pi_1 \frac{\bar{Y}_i^{1-\gamma}}{1-\gamma} + \pi_0 \right))) + (1 - HAPPY_{it}) \times \log(1 - \Phi(h\left(\pi_1 \frac{\bar{Y}_i^{1-\gamma}}{1-\gamma} + \pi_0 \right))) \right),$$

where $\Phi(.)$ denotes the standard normal cumulative density function. The outcome of this maximization problem is an estimated transfer function $\hat{h}(.)$, which will depend on our choice of γ.

Next, we define the mapping from our von Neumann-Morgenstern utility measure v to the utility proxy *HAPPY* as $\hat{g}(.) = \Phi(\hat{h}(.))$. We use the estimated mapping $\hat{g}(.)$ and set $\beta_2 = 1-\gamma$ when we estimate equation (15), which identifies state dependence by the interaction between permanent income and health in a panel model with individual fixed effects. We estimate equation (15) by maximum likelihood. Finally, using our estimated fixed effects, we estimate equation (16) which identifies the marginal utility of permanent income (β_3).

We report bootstrapped standard errors clustered by individual for two reasons. First, this is a three-step estimator – the first step estimates $h(.)$, the second step estimates β_1, fixed effects (α_is), and other parameters given $\hat{h}(.)$, and the third step estimates β_3 given the fixed effect estimates. Second, we are most interested in the magnitude of state dependence ($\sigma\beta_1/\beta_3$) and bootstrapping allows us to take into account the covariance between β_1 and β_3, which are estimated in two separate equations. A single iteration of the three-step estimator takes about 4 hours to run, so we only run 100 iterations to compute our bootstrapped standard errors. We report p-values based on asymptotic t-tests constructed from our point estimate and the bootstrapped standard errors.

Appendix E: Estimates of State Dependence when Second-Period Wealth Varies with Health

We model the effect of health on second-period wealth by allowing the individual to receive a state-dependent income flow in the second period. In particular, let the individual receive *net* income $\tilde{N}(S)$ in period 2 (in addition to the permanent income Y received in period 1). We think of $\tilde{N}(S)$ as consisting of effects of health on labor income and household production, informal transfers from friends and family that depend on health status, or resources that would have otherwise been used on an outside state-independent consumption good (that falls outside out formal model, such as bequests).

The lifetime budget constraint now becomes: $Y(1-\tau)=C_1+\frac{1}{1+r}(C_2+(1-b)H-\tilde{N}(S))$. Further, assume that $\tilde{N}(0)=0$, and $\tilde{N}(1)=N$. The introduction of state-dependent income does not alter the individual's choice between consumption goods and health services except that second-period wealth in the sick state is now $W+N$ instead of W. Updating equations (4) and (8) from Section 2.1 accordingly, we find that second-period utility is now given by:

$$U_2=\frac{1}{1-\gamma}W^{1-\gamma} \quad \text{if healthy and} \tag{E.1}$$

$$U_2=\frac{1}{1-\gamma}(1+\varphi_1)\left(1+(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\varphi_2^{1/\gamma}\right)^{\gamma}(W+N)^{1-\gamma} \quad \text{if sick.} \tag{E.2}$$

Since W is chosen before the random variable health status is realized, W is independent of health status for any individual. We now express the effect of health on the marginal utility of wealth as a fraction of the marginal utility of wealth in the healthy state. Note, however, that the level of second-period wealth is not held constant in this ratio of marginal utilities (due to the state-dependent income):

$$\frac{\frac{dU_{2,S=1}}{dW}-\frac{dU_{2,S=0}}{dW}}{\frac{dU_{2,S=0}}{dW}}=(1+\varphi_1)\left(1+(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\varphi_2^{1/\gamma}\right)^{\gamma}(1+N/W)^{-\gamma}-1\,. \tag{E.3}$$

We simplify this expression by defining net income shocks n as a fraction of second-period wealth (so $n=N/W$), dividing equation (6) by (7), substituting the resulting expression into (E.3), and rearranging:

$$\frac{dU_{2,S=1}/dW-dU_{2,S=0}/dW}{dU_{2,S=0}/dW}=\left(1+(1-b)m\right)^{\gamma}(1+\varphi_1)\left(1+n\right)^{-\gamma}-1\,. \tag{E.4}$$

This expression corresponds to equation (14) in Section 2.1, except for the inclusion of the term $(1+n)^{-\gamma}$, which takes into account that wealth is not held constant when comparing the marginal utility of wealth in the healthy and sick state. Specifically, because the elasticity of marginal utility with respect to consumption (or wealth) is $-\gamma$, the marginal utility of wealth (or consumption) in the sick state increases whenever state-dependent income causes wealth (or consumption) in the sick state to fall.

Equation (E.4) also gives insight into the optimal level of state-dependent income. This income should depend on health such that the marginal utility of wealth is equalized across states of the world. So, the optimal level of net state-dependent income is:

$$n^* = \left(1+\varphi_1\right)^{1/\gamma}(1+(1-b)m)-1 \;\approx\; \varphi_1/\gamma+(1-b)m \,. \tag{E.5}$$

Thus, absent state dependence ($\varphi_1 = 0$), the optimal level of state-dependent income equals the co-payments for medical services, i.e., it is optimal to receive a lump-sum income transfer in the sick state that is sufficient to cover the co-payments. However, if the marginal utility of consumption is lower in poor health ($\varphi_1 < 0$), then the optimal lump-sum transfer in the sick state is less than the co-payments. Similarly, if $\varphi_1 > 0$, the lump-sum payment would exceed the co-payments so that non-medical consumption is higher when sick than when healthy.

Even though we cannot obtain a closed form solution for W when there is state-dependent income, it is clear that second-period wealth is increasing in permanent income. We parameterize this relationship as $W = \rho_0 Y^{\rho_1}$, with $\rho_0 > 0$ and $\rho_1 > 0$. Modeling second-period resources as a monotonically increasing function of permanent income also captures cases in which the effective interest rate, discount rate, or probability of diseases varies by permanent income. It follows that second-period indirect utility, $v(Y,S)$, equals:

$$v(Y,0) = \frac{1}{1-\gamma}W^{1-\gamma} = \frac{\rho_0^{1-\gamma}}{1-\gamma}Y^{(1-\gamma)\rho_1} \text{, and} \tag{E.6}$$

$$\begin{aligned} v(Y,1) &= \frac{1}{1-\gamma}(1+\varphi_1)\left(1+\varphi_2^{1/\gamma}(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\right)^{\gamma}\left((1+n)W\right)^{1-\gamma} \\ &= \frac{\rho_0^{1-\gamma}}{1-\gamma}(1+\varphi_1)\left(1+\varphi_2^{1/\gamma}(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\right)^{\gamma}\left(1+n\right)^{1-\gamma}Y^{(1-\gamma)\rho_1} \end{aligned} . \tag{E.7}$$

Thus, running the regression given by equation (11) yields the following estimate for the parameter ratio β_1/β_3:

$$\beta_1/\beta_3 = (1+\varphi_1)\left(1+\varphi_2^{1/\gamma}(1+\varphi_1)^{-1/\gamma}(1-b)^{1-1/\gamma}\right)^{\gamma}\left(1+n\right)^{1-\gamma}-1 \tag{E.8}$$

This expression is the same as our original expression for the parameter ratio (equation (13) in Section 2.1), but now includes the term $(1+n)^{1-\gamma}$. Dividing equation (6) by (7) and substituting the resulting expression into (E.8) yields:

$$\beta_1/\beta_3 = (1+\varphi_1)\left(1+m(1-b)\right)^{\gamma}\left(1+n\right)^{1-\gamma}-1 \approx \varphi_1+\gamma m(1-b)+n(1-\gamma) \tag{E.9}$$

This expression formalizes the intuition developed from Figure 2 concerning the bias from having net state-dependent income. If $\gamma = 1$, the ratio β_1/β_3 yields an unbiased estimate of the state dependence in the marginal utility of wealth (evaluated at constant wealth), even in the presence of state-dependent net income shocks. For $\gamma>1$, the bias has the opposite sign as the sign of the net state-dependent income shocks. So, if negative health shocks reduce wealth (as seems likely), then the true degree of state dependence in the marginal utility of wealth evaluated at constant wealth is more negative (or less positive) than our estimated parameter ratio β_1/β_3. Since state-dependent income does not affect the correction factor $\left(1+m(1-b)\right)^{-\gamma}$ by which the ratio of marginal utilities of wealth needs to be multiplied to obtain the ratio of marginal utilities of consumption, the direction of the bias of state-dependent income on the effect of health on the marginal utility of consumption has the same sign as bias in the effect of health on the marginal utility of wealth.

In certain cases, individuals may be able to choose the level of net state-dependent income. This may occur if there are well functioning (informal) insurance networks of if the individual has an outside good of which the utility does not dependent on health. In such cases, individuals would set n such that the marginal utility of wealth is equalized across health states, so $n^* = \left(1+\varphi_1\right)^{1/\gamma}(1+(1-b)m)-1$. Substituting this expression into equation (E.9) yields:

$$\beta_1 / \beta_3 = \left[(1+\varphi_1)\left(1+m(1-b)\right)^{\gamma} \right]^{1/\gamma} - 1\,. \qquad \text{(E.10)}$$

As before, there is no bias if $\gamma=1$ because in that case equation (E.10) reduces to equation (14). If $\gamma>1$, the estimate of state dependence in the marginal utility of wealth is biased towards zero. To see this, note that if the expression between square brackets is raise to a power $1/\gamma<1$, the right-hand side of equation (E.10) becomes closer to zero. This implies that the parameter ratio β_1/β_3 will be biased towards zero if state-dependent income is chosen optimally.

We can also model predictable or temporary health changes in this framework. Individuals who can predict health changes will adjust their savings such that the marginal utility of second-period wealth is equal to the marginal utility of first-period wealth. Such individuals can effectively self-insure, so we can think of them as selecting n such that the marginal utility of wealth is equalized across periods.

Appendix F: Robustness Checks and Additional Results

This section reports additional results summarized in the main text. Summary statistics for additional variables discussed in this section can be found in Appendix Table A1.

Is wealth pre-determined in our sample? Some suggestive evidence

In Table 6, we examine how current income and consumption change as health deteriorates using all households in our baseline sample with adequate consumption data (see online Appendix B for details on the consumption data set). Appendix Table A2 reports results estimating the model for the subsample of individuals who are always single and for the subsample of non-single households. The results in this table show no evidence of any changes in consumption associated with health shocks. The results also show no evidence that the changes in these variables associated with health shocks are systematically related to permanent income. Appendix Table A3 reports results from alternative specifications which estimate separate coefficients for singles and couples (non-singles) and the results are qualitatively similar. Lastly, Appendix Table A4 reports results from regressions which include dummies for each disease separately (and interacts each disease dummy with household type) rather than use the average number of diseases per person. These results also provide no consistent evidence that health shocks are associated with a significant increase in income or consumption.[7]

Differential trends over time in utility by permanent income

If the consumption path of the poor increases more (or declines less) than that of the rich, this tendency could show up in our estimates as negative state dependence. Since the number of diseases increases over time, it could look like the rich have a greater drop in utility with the onset of a disease simply due to different trends in underlying utility. Reassuringly, we find suggestive evidence that the consumption path of the poor declines (in percentage terms) relative to that of the rich over time, though our preferred estimate in column 1 of Appendix Table A5 is not statistically significant at conventional levels ($p = 0.200$). However, all columns of Table A5 suggest that, if anything, the consumption path of the poor declines relative to the rich, which would bias us against our finding negative state dependence.

An alternative way to investigate this issue would be to add an interaction of permanent income with time (or equivalently, current age) to our baseline specification. Unfortunately, the high collinearity between time and the onset of a disease makes it hard to disentangle the two effects; not surprisingly, our estimate of the interaction of permanent income with health becomes extremely imprecise (see column 3 of Appendix Table A6).

Differential effects of other time-varying covariates by permanent income

Our estimates of the differential effect of health changes by permanent income may in part capture differential effects of other time-varying covariates by permanent income. We therefore allowed the effect of permanent income to vary not only with number of diseases but also with martial status and with household size. As shown in column 2 of Appendix Table A6, the estimate of the interaction term of permanent income and number of diseases remains similar in magnitude to our baseline estimate (reproduced in column 1), but is now only significant at the

[7] Of the 27 coefficients estimated in Panel B, only one is statistically significant at conventional levels: the coefficient on both household members having cancer. This result is likely spurious, as it is estimated off of only 14 households and is implausibly large (the point estimate suggests that if both household members get cancer that household consumption increases by roughly 50%).

10-percent level.

Differential reporting of diseases by permanent income

If, conditional on reporting a disease, the severity of the disease varies by permanent income, then this would violate our identifying assumption and bias our inferences. For example, if, conditional on reporting a disease, the severity is greater for the rich than the poor, then we would estimate a larger decline in utility for those with higher permanent income, thus biasing us toward finding negative state dependence; the converse would bias us in the opposite direction.[8]

The existing evidence suggests that reporting differences by socio-economic status (SES) likely bias against our finding of negative state dependence. Banks et al. (2006) compare the education-disease gradient for individuals aged 40 to 70 in the 1999-2002 National Health and Nutrition Examination Survey (NHANES) based on self-reported health measures and on biological measures.[9] For hypertension, the gradients using the two different health measures are virtually indistinguishable; for diabetes, there is some evidence of under-reporting by individuals of lower education (Banks et al., 2006 Table 4). In Appendix Table A7, we present our own analysis of the HRS data, which shows that conditional on reporting that a doctor has told them they have a particular disease, individuals of higher permanent income are less likely to report conditions that indicate a more severe form of the disease. This suggests that the threshold for reporting a disease is higher for the poor. Under the reasonable assumption that this under-reporting by the poor exacerbates the difference in health status among the poor between those who report that they have a diseases and those who do not, this would bias against our finding of negative state-dependent utility.

The effect of onset of individual diseases on marginal utility of consumption

Our approach yields an estimate of the average effect of deteriorating health on the marginal utility of consumption in a representative sample of the elderly and near elderly. This is the economically relevant parameter for savings and health insurance decisions; indeed, we consider it a strength of our approach that it yields estimates of the average effect of common health conditions in the population on the marginal utility of consumption. However, because the marginal utility of consumption may not change with the onset of each disease in the same way, we examine the effect on marginal utility of each disease separately.

Appendix Table A8 interacts each of the seven disease dummies with the log of permanent income and includes all seven interaction terms and the seven disease dummies in one regression. The first seven columns give the estimates on the interaction term, the disease dummy for each of the seven diseases, and log permanent income. Not surprisingly, the precision of the estimates is often considerably worse than the baseline number of diseases variable. Indeed, we estimate statistically significant state dependence only for blood pressure and lung disease. Nonetheless, with the exception of heart disease and arthritis, the point estimates on the interaction terms are uniformly negative; moreover, we are unable to reject at the 10% level the hypothesis that all seven interaction terms are equal (p-value = 0.131). In the final column, we show that the prevalence-weighted sum of the seven interaction terms from this specification is statistically significant and that the magnitude (–10.5%) is very similar to our baseline result of

[8] Note that there is no bias from differential rates of disease occurrence for individuals of different permanent income; this rate simply affects the frequency with which we observe the sick state.

[9] Both the NHANES and HRS self-reported measures are based on the question "has a doctor ever told you that you have X" rather than the respondent's subjective assessment, which may mitigate potential differential reporting.

–11.2%.[10]

Symptomatic versus asymptomatic diseases

In Appendix Table A9, we investigate whether the drop in marginal utility differs between symptomatic and asymptomatic diseases. In column 1, we classify lung disease, stroke, arthritis, and cancer as symptomatic diseases and high blood pressure, heart disease, and diabetes as asymptomatic diseases. find no evidence that the effect of an additional disease is different for symptomatic and asymptomatic diseases (p-value = 0.590). In column 2, we show that the results are similar if cancer is instead classified as an asymptomatic disease (p-value = 0.682).

Tests for nonlinear effects

We also examine whether the magnitude of the drop in marginal utility from an additional disease depends on the number of diseases that the individual already has. In Appendix Table A10, we show that we find no evidence of such nonlinearities and cannot reject the hypothesis that the effect of an additional disease is the same for each number of pre-existing diseases (p-value = 0.355).

Alternative specifications

Appendix Table A11 reports the results from several additional sensitivity analyses. Column 1 replicates our baseline results from Table 2. Subsequent columns always report results for one specified change relative to this baseline. To facilitate comparability of the magnitude of state-dependent utility across these and later analyses, the bottom row reports the implied percent change in marginal utility for a healthy person associated with a one-standard-deviation decline in health (i.e., $\sigma\beta_1/\beta_3$). This provides a scale-free way of comparing different estimates.

Column 2 shows that the results are not sensitive to excluding the demographic controls (X_{it}). Column 3 restricts the analysis to individuals who are always single. Since three-fifths of our sample is married, our estimates are potentially confounded by correlations in health changes within a couple and by any effects that spousal health has on one's own marginal utility. As shown in Column 3, the point estimate of state dependence is still negative among single individuals. However, based on just 30 percent of the original sample, the estimate is no longer statistically significant. Column 4 shows that the estimate of β_1 is unaffected by adding additional covariates for spousal health and the interaction of spousal health with log permanent income. Interestingly, the results suggest that while a deterioration in spousal health has a similar impact on an individual's utility as a deterioration in own health, a deterioration in spousal health has no detectible effect on an individual's marginal utility.

Oswald and Powdthavee (2007) show that individuals partly adapt to disability; the onset of disability reduces happiness more in the short run than in the longer run. While their finding concerns adaptation of the level of utility, it raises the question of whether marginal utility also adapts to health shocks. In column 5, we test for such habituation effects by adding a two-year lag of the number of diseases as well as this lag interacted with log permanent income as regressors. We find that the coefficient on permanent income interacted with lagged number of diseases is small and statistically insignificant. In other words, the decline in marginal utility after a negative health shock does not appear to diminish over time.

In column 6, we estimate the baseline specification to the sample of individuals aged 65 or

[10] Prevalence-weighting is based on the person-years in the baseline sample that have the disease dummy turned on.

older irrespective of their labor force status or insurance status. The resulting estimate of state dependence (-13.7%) is very similar to our baseline estimate, mitigating the concerns that our results are be specific to a sample that is selected to have insurance and to be out of the labor force.

Alternative measures of key variables

Lastly, Appendix Table A12 investigates the sensitivity of our results to alternative measures of our key variables. Columns 2 and 3 show that we continue to estimate negative and statistically significant state dependence (i.e., $\beta_1 < 0$) if we replace our permanent income measure $\bar{Y}$ with education and wealth, respectively, which are other reasonable proxies for consumption opportunities; in both columns, the magnitude of our estimate of state dependence (i.e., $\sigma\beta_1/\beta_3$ shown in the bottom row) is slightly larger than in the baseline estimate. Columns 4 through 7 show that we continue to obtain negative and usually at least marginally statistically significant estimates of state dependence if, instead of our baseline measure of the number of chronic diseases, we use other standard measures of health, including (respectively) limitations to activities of daily living (ADLs), limitations to instrumental activities of daily living (IADLs), other functional limitations (OFLs), and a health index measure in the spirit of Dor et al. (2006) in which we sum the three limitation measures and the individual's reported pain score.

The last three columns of Table A12 report results for alternative utility proxies. In addition to the baseline utility proxy (the subjective well-being question "Much of the past week I felt happy [yes or no]?"), the HRS contains seven other items from Radloff's (1977) CES-D depression scale. These items have a similar format but instead of "I felt happy" substitute "I enjoyed life", "I felt sad", "I felt lonely", "I felt depressed", "I felt that everything I did was an effort", "my sleep was restless", and "I could not get going". We code these 0/1 measures such that 1 corresponds to higher utility and define a *CESD-8* variable as the sum of the answers over these eight questions. We also follow Smith et al. (2005) by defining a subjective well-being measure *CESD-4* that consists of the sum of answers to the first four items from the Radloff scale; these focus more on happiness and less on the feelings more typically associated with depression or stress.

Columns 8 and 9 of Table A12 report results of estimating equations (15) and (16) using *CESD-8* and *CESD-4* respectively as our utility proxy. Both have desirable properties for a utility proxy in that they both decline with worsening health (i.e., $\beta_4 < 0$) and increase with permanent income (i.e., $\beta_3 > 0$). Most importantly, both indicate a decline in the marginal utility of permanent income associated with deteriorating health, i.e., $\beta_1 < 0$, though this decline is only statistically significant for *CESD-8*. The bottom row of Table A12 shows that the magnitude of the estimated state dependence (i.e., $\sigma\beta_1/\beta_3$) is somewhat smaller than in our baseline, although it lies within the baseline's 95-percent confidence interval.[11] In column 10, we draw on a similar sample of individuals in a different data set – the British Household Panel Survey (BHPS) – to

[11] Smith et al. (2005) compare the impact of moving from no ADL limitations to at least two ADL limitations on CESD-4 by household net worth. They find that those with below-median net worth experience a significantly larger drop in subjective well-being as a result of acquiring two ADL limitations than those with above-median net worth. Because their sample also includes individuals in the labor force and those without health insurance, these estimates could be driven by negative consumption shocks as a result of the onset of disability rather than by positive state-dependent utility. Indeed, the estimate on our interaction term also becomes positive if we add to our sample individuals in the labor force and individuals without health insurance, but we argue that the interaction term in this case no longer estimates state dependence because it is biased by the direct effect of disability on consumption.

perform the analysis with subjective life satisfaction (measured on a 7-point scale), a commonly used alternative subjective well-being measure; online Appendix B describes these data in more detail. We continue to estimate negative state-dependent utility (i.e., $\beta_1 < 0$) with a magnitude (i.e., $\sigma\beta_1/\beta_3$) of -14.0%, which is quite similar to our baseline estimate of -11.2% using different data, from a different country, with a different SWB measure. However, in the considerably smaller sample, our estimate of state-dependent utility is no longer statistically significantly different from zero.

References for all the online appendices

Atkinson, A.B., L. Rainwater, and T. M. Smeeding. 1995. "Income Distribution in OECD Countries." *OECD Social Policy Studies* No. 18: http://www.oecd.org/dataoecd/61/52/35411111.pdf

Banks, James, Michael Marmot, Zoe Oldfield, and James Smith. 2006. "Disease and Disadvantage in the United States and England." *Journal of the American Medical Association* 295(17): 2037-2045.

Barro, Robert J. 2009. "Rare Disasters, Asset Prices, and Welfare Costs." *American Economic Review* 99:1, 243-264.

Chernozhukov, Victor, Ivan Fernandez-Val, and Alfred Galichon. 2009. "Improving Estimators of Monotone Functions by Rearrangement," *Biometrika* 99, 559-575.

Dor, Avi, Joseph Sudano, and David Baker. 2006. "The Effect of Private Insurance on the Health of Older, Working Age Adults: Evidence from the Health and Retirement Study." *Health Services Research* 41(3): 759-787.

Manning, Willard G., Joseph P. Newhouse, Naihua Duan, Emmett B. Keeler, Arleen Leibowitz, and M. Susan Marquis. 1987. "Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment." *American Economic Review* 77(3): 251-277.

Oswald, Andrew J. and Nattavudh Powdthavee. 2007. "Does Happiness Adapt? A Longitudinal Study of Disability with Implications for Economists and Judges," *Journal of Public Economics*, forthcoming.

Radloff, Lenore S. 1977. "The CES-D Scale: A Self-Report Depression Scale for Research in the General Population." *Applied Psychological Measurement* 1(3): 385-401.

Shiller, Robert. 1989. *Market Volatility*, MIT Press, Cambridge MA.

Smith, Dylan M., Kenneth M. Langa, Mohammed U. Kabeto, and Peter A. Ubel. 2005. "Health, Wealth, and Happiness: Financial Resources Buffer Subjective Well-Being After the Onset of a Disability." *Psychological Science* 16(9): 663-666.

TABLE A1

ADDITIONAL DESCRIPTIVE STATISTICS

	Sample: Age ≥ 50 & Not in labor force & Has health insurance							
	Obs	Mean	Std. dev.	5th percentile	Median	95th percentile	Std. dev. (within-indiv.)	
Demographics								
NUM_WAVE	45447	4.52	1.50	2	4	7	0	— Number of waves that respondent was interviewed.
$\bar{Y}$ (Permanent income, $)	45447	29224	33297	6236	20667	77285	0	— Permanent income constructed by taking the average across all waves of total household income plus a 5 percent annual draw down of current financial wealth. The average is then adjusted using an OECD-style adjustment (divide by 1.0 if single, and divide by 1.7 if married and living with spouse).
FEMALE	45447	0.63	0.48	0	1	1	0	
NON_WHITE	45447	0.13	0.33	0	0	1	0	
SINGLE	45447	0.40	0.49	0	0	1	0.21	
AGE	45447	72.39	9.00	57	73	87	3.28	
HOUSEHOLD_SIZE	45447	1.99	1.00	1	2	4	0.56	— Household size includes all residents of household (including spouse).
Health Measures								
NUM_DISEASE	45447	1.95	1.30	0	2	4	0.63	— Sum of Yes/No "Has a doctor ever told you have *D*?" (0-7)
SPOUSE_NUM_DISEASE	45447	1.03	1.30	0	0	4	0.71	— Sum of spouse's Yes/No "Has a doctor ever told you have *D*?" (0-7)
ADL_TOTAL	45447	0.44	1.05	0	0	3	0.74	— Sum of Yes/No "Does anyone help you *A*?" (0-6)
IADL_TOTAL	45384	0.41	0.89	0	0	2	0.67	— Sum of Yes/No "Are you able to *I*?" (0-6)
OFL_TOTAL	45446	2.75	2.70	0	2	8	1.69	— Sum of "How difficult is *O*?" (1 = Very or somewhat difficult) (0-10)
HEALTH_INDEX	45334	4.21	4.50	0	3	14	2.67	— Sum of severity of pain (0-3), ADL, IADL, and OFL (0-25)
Utility Proxies								
HAPPY	45447	0.87	0.34	0	1	1	0.28	— Yes/No "Much of the time the past week I felt happy?"
CESD-8	45447	6.32	2.01	2	7	8	1.38	— Sum of Yes/No "Much of the time the past week I felt/was *C*?"
CESD-4	45447	3.38	1.05	1	4	4	0.79	— Subset of 4 out of 8 *CESD-8* questions (enjoy life, happy, sad, lonely).

Notes: Set of diseases: *D* = {hypertension, diabetes, cancer, heart disease, chronic lung disease, stroke, arthritis}. Set of Activities of Daily Living (ADLs): *A* = {dress, bathe or shower, walk across a room, eat (such as cutting up your food), get in and out of bed, use the toilet (including getting up and down)}. Set of Instrumental Activities of Daily Living (IADLs): *I* = {prepare hot meals, shop for groceries, make telephone calls, take medications, use a map, use a calculator}. Set of Other Functional Limitations (OFLs): *O* = {walk several blocks, walk one block, sit up for about 2 hours, get up from a chair, climb several flights of stairs, climb one flight of stairs, stoop/kneel/crouch, pick up a dime, extend your arms above shoulder level, push large objects like a living room chair}. The severity of pain is measured as no pain (0), mild pain (1), moderate pain (2), or severe pain (3). Set of CESD items: *C* = {depressed, everything I did was an effort, my sleep was restless, happy, lonely, enjoyed life, sad, could not 'get going'}. Spouse diseases set to 0 if the respondent is single.

TABLE A2
INCOME AND CONSUMPTION RESPONSE TO DISEASE (ALTERNATIVE SAMPLES)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Sample restriction:	Single Households Only						Non-Single Households Only					
Dependent variable:	Current income		Total consumption		Non-durable consumption		Current income		Total consumption		Non-durable consumption	
Number of Diseases per Person$_{it}$	0.003	-0.001	0.035	0.042	0.041	0.049	0.035	0.034	0.026	0.023	0.021	0.014
	(0.010)	(0.012)	(0.047)	(0.047)	(0.051)	(0.051)	(0.013)	(0.013)	(0.041)	(0.042)	(0.045)	(0.045)
	[0.758]	[0.957]	[0.461]	[0.371]	[0.425]	[0.336]	[0.007]	[0.009]	[0.534]	[0.591]	[0.635]	[0.756]
Number of Diseases per Person$_{it}$ × $\log(\bar{Y}_i)$		-0.015		0.037		0.045		0.017		0.016		0.038
		(0.017)		(0.050)		(0.056)		(0.018)		(0.047)		(0.047)
		[0.370]		[0.461]		[0.427]		[0.333]		[0.743]		[0.414]
Within-Household std. dev. in Number of Diseases per Person$_{it}$	0.615	0.615	0.456	0.456	0.456	0.456	0.504	0.504	0.396	0.396	0.396	0.396
R^2	0.764	0.764	0.775	0.775	0.778	0.778	0.780	0.780	0.777	0.777	0.780	0.781
N	17412	17412	2602	2602	2602	2602	19309	19309	2412	2412	2412	2412

Notes: Table reports results from a regression of the dependent variable on the covariates shown in the table, household fixed effects, wave fixed effects, and controls for a quadratic in average household age and household size. In columns (1) through (6), the sample is restricted to households where the respondent is currently single, while in columns (7) through (12) the sample is restricted to households where the respondents are not single. In all columns, the Number of Diseases per Person is the total number of diseases in the household divided by the number of respondents in the household. In columns (1), (2), (7), (8) the dependent variable is the current household income. All consumption measures include out-of-pocket medical expenditures. The dependent variables in remaining columns are household consumption measures. All dependent variables are in logs. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each household over time, are in parentheses and p-values are in brackets.

TABLE A3
INCOME AND CONSUMPTION RESPONSE TO DISEASE (ALTERNATIVE SPECIFICATIONS)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Current income		Total consumption		Non-durable consumption	
$SINGLE_{it}$ × Number of Diseases per $Person_{it}$	0.014	0.010	0.007	0.014	0.008	0.017
	(0.009)	(0.011)	(0.043)	(0.042)	(0.046)	(0.046)
	[0.131]	[0.343]	[0.864]	[0.731]	[0.863]	[0.718]
(1 - $SINGLE_{it}$) × Number of Diseases per $Person_{it}$	0.021	0.020	0.072	0.069	0.075	0.067
	(0.011)	(0.011)	(0.039)	(0.041)	(0.042)	(0.043)
	[0.060]	[0.068]	[0.065]	[0.088]	[0.079]	[0.119]
$SINGLE_{it}$ × Number of Diseases per $Person_{it}$ × $\log(\overline{Y}_i)$		-0.016		0.038		0.045
		(0.017)		(0.050)		(0.056)
		[0.349]		[0.453]		[0.419]
(1 - $SINGLE_{it}$) × Number of Diseases per $Person_{it}$ × $\log(\overline{Y}_i)$		0.013		0.015		0.040
		(0.018)		(0.047)		(0.048)
		[0.473]		[0.747]		[0.406]
R^2	0.784	0.784	0.776	0.776	0.780	0.780
N	36721	36721	5014	5014	5014	5014

Notes: Table reports results from a regression of the dependent variable on the covariates shown in the table, household fixed effects, wave fixed effects, and controls for a quadratic in average household age, household size. In all columns, the Number of Diseases per Person is the total number of diseases in the household divided by the number of respondents in the household. The dependent variable in columns (1) and (2) is the current household income. The dependent variables in remaining columns are household consumption measures. All consumption measures include out-of-pocket medical expenditures. All dependent variables are in logs. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each household over time, are in parentheses and p-values are in brackets.

TABLE A4

INCOME AND CONSUMPTION RESPONSES FOR INDIVIDUAL DISEASES

Disease *X* =	Blood pressure	Diabetes	Cancer	Lung Disease	Heart Disease	Stroke	Arthritis
	Panel A: Dependent Variable is Current Income						
Any Household Member has Disease *X*	-0.009	0.065	-0.044	0.077	0.002	-0.009	0.009
	(0.023)	(0.027)	(0.034)	(0.042)	(0.026)	(0.033)	(0.017)
	[0.697]	[0.018]	[0.192]	[0.065]	[0.941]	[0.791]	[0.592]
Any Household Member has Disease *X* × (1 - *SINGLE*)	0.047	-0.047	0.033	-0.074	0.014	-0.007	0.005
	(0.032)	(0.036)	(0.040)	(0.049)	(0.032)	(0.042)	(0.023)
	[0.135]	[0.191]	[0.406]	[0.128]	[0.662]	[0.871]	[0.838]
All Household Members have Disease *X* × (1 - *SINGLE*)	-0.023	0.076	-0.062	0.080	-0.054	0.028	-0.016
	(0.022)	(0.054)	(0.046)	(0.073)	(0.029)	(0.065)	(0.017)
	[0.296]	[0.157]	[0.178]	[0.274]	[0.064]	[0.665]	[0.343]
R^2	0.784						
N	36721						
p-value of F-test that all coefficients = 0	0.138						
	Panel B: Dependent Variable is Total Consumption						
Any Household Member has Disease *X*	0.025	0.118	-0.179	-0.057	0.017	0.145	-0.018
	(0.077)	(0.143)	(0.173)	(0.123)	(0.102)	(0.186)	(0.116)
	[0.742]	[0.407]	[0.300]	[0.645]	[0.869]	[0.436]	[0.878]
Any Household Member has Disease *X* × (1 - *SINGLE*)	0.030	-0.109	0.260	0.014	0.150	0.049	-0.036
	(0.103)	(0.166)	(0.196)	(0.144)	(0.124)	(0.236)	(0.138)
	[0.773]	[0.514]	[0.186]	[0.921]	[0.225]	[0.837]	[0.791]
All Household Members have Disease *X* × (1 - *SINGLE*)	-0.104	-0.040	0.478	0.074	-0.003	-0.138	0.051
	(0.073)	(0.186)	(0.175)	(0.146)	(0.107)	(0.204)	(0.059)
	[0.153]	[0.829]	[0.006]	[0.612]	[0.981]	[0.499]	[0.394]
R^2	0.777						
N	5014						
p-value of F-test that all coefficients = 0	0.259						
	Panel C: Dependent Variable is Non-Durable Consumption						
Any Household Member has Disease *X*	0.048	0.192	-0.210	-0.063	0.013	0.158	-0.081
	(0.082)	(0.147)	(0.199)	(0.134)	(0.108)	(0.195)	(0.130)
	[0.553]	[0.190]	[0.292]	[0.640]	[0.904]	[0.418]	[0.531]
Any Household Member has Disease *X* × (1 - *SINGLE*)	-0.005	-0.185	0.278	-0.010	0.177	0.012	0.030
	(0.110)	(0.175)	(0.224)	(0.152)	(0.129)	(0.246)	(0.154)
	[0.967]	[0.290]	[0.214]	[0.947]	[0.168]	[0.960]	[0.847]
All Household Members have Disease *X* × (1 - *SINGLE*)	-0.123	-0.098	0.521	0.169	0.014	-0.196	0.079
	(0.077)	(0.193)	(0.171)	(0.132)	(0.114)	(0.224)	(0.063)
	[0.108]	[0.610]	[0.002]	[0.199]	[0.901]	[0.381]	[0.211]
R^2	0.781						
N	5014						
p-value of F-test that all coefficients = 0	0.086						

Notes: Each panel reports coefficients from a single OLS regression. This table shows results from estimating a modified version of the regression shown in Appendix Table A3 where the Number of Diseases per Person is replaced with seven disease dummies indicating whether any respondent in the household has the particular disease listed in the column heading. The disease dummies are interacted with a dummy for whether or not the household is a couple. The dependent variable in Panel A is the current household income. The dependent variables in the remaining panels are household consumption measures. All consumption measures include out-of-pocket medical expenditures. All dependent variables are in logs. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each household over time, are in parentheses and p-values are in brackets.

TABLE A5
DIFFERENTIAL CONSUMPTION TRENDS BY PERMANENT INCOME

	(1)	(2)	(3)	(4)
Dependent variable:	Total consumption		Non-durable consumption	
Number of Diseases per Person$_{it}$	0.033	0.024	0.035	0.028
	(0.033)	(0.055)	(0.035)	(0.060)
	[0.310]	[0.669]	[0.329]	[0.648]
$t \times \log(\bar{Y}_i)$	0.021	0.062	0.027	0.069
	(0.016)	(0.025)	(0.018)	(0.028)
	[0.200]	[0.015]	[0.129]	[0.015]
R^2	0.776	0.768	0.780	0.770
N	5014	1898	5014	1898
Sample restrictions:				
All households in baseline sample	X		X	
Limit to always single		X		X

Notes: Table reports results from an OLS regression of the dependent variable in the column heading on the covariates shown in the table, household fixed effects, wave fixed effects, and controls for a quadratic in average household age, household size, and a dummy for whether the household is single. The dependent variables are various household consumption measures. All dependent variables are in logs. The Number of Diseases per Person is the total number of diseases in the household divided by the number of respondents in the household. In columns (2) and (4), the sample is limited to individuals in the baseline sample who are always single. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each household over time, are in parentheses and p-values are in brackets.

TABLE A6
ADDITIONAL INTERACTIONS OF PERMANENT INCOME

	(1)	(2)	(3)
	Baseline	Other Permanent Income Interactions	
$NUM\_DISEASE_{it} \times \log(\bar{Y}_i)$ (β_1)	-0.009	-0.006	0.004
	(0.004)	(0.004)	(0.005)
	[0.018]	[0.099]	[0.410]
$\log(\bar{Y}_i)$ (β_3)	0.048	0.044	0.023
	(0.003)	(0.003)	(0.003)
	[0.000]	[0.000]	[0.000]
$NUM\_DISEASE_{it}$ (β_4)	-0.011	-0.011	-0.010
	(0.003)	(0.003)	(0.003)
	[0.001]	[0.002]	[0.002]
$HOUSEHOLD\_SIZE_{it} \times \log(\bar{Y}_i)$		0.006	0.005
		(0.005)	(0.005)
		[0.182]	[0.235]
$SINGLE_{it} \times \log(\bar{Y}_i)$		-0.037	-0.030
		(0.014)	(0.014)
		[0.007]	[0.031]
$AGE_{it} \times \log(\bar{Y}_i)$			-0.003
			(0.001)
			[0.000]
R^2	0.474	0.474	0.474
N	45447	45447	45447
Number of individuals	11514	11514	11514
Within-person standard deviation of $NUM\_DISEASE_{it}$ (σ)	0.625	0.625	0.625
% change in marginal utility for a 1 std. dev. change in $NUM\_DISEASE_{it}$ $(\sigma\beta_1/\beta_3)$	-11.2%	-8.5%	10.2%
	[0.018]	[0.099]	[0.411]

Notes: Column (1) reports the results from the baseline specification in Table 2; see notes to Table 2 (Panel A) for more details. Subsequent columns report alternative specifications which include additional interactions of permanent income with various household demographics. Standard errors are in parentheses and are adjusted to allow for an arbitrary variance-covariance matrix for each individual over time. P-values are in brackets; the p-value for $\sigma\beta_1/\beta_3$ is bootstrapped based on 10,000 iterations, resampling individuals with replacement.

TABLE A7
DISEASE NUMBER AND SEVERITY BY PERMANENT INCOME

	(1)	(2)	(3)	(4)	(5)	(6)
		Sample: has {lung disease, diabetes, stroke}				
Dependent variable:	Number of diseases	Taking oxygen for lung disease	Severe diabetes, (1-2)	Severe diabetes dummy	Severe stroke, (1-7)	Severe stroke dummy
$\log(\bar{Y}_i)$	-0.231	-0.037	-0.028	-0.025	-0.194	-0.037
	(0.016)	(0.010)	(0.013)	(0.013)	(0.050)	(0.014)
	[0.000]	[0.000]	[0.031]	[0.047]	[0.000]	[0.010]
R^2	0.037	0.017	0.029	0.025	0.019	0.010
N	45447	4864	7927	7927	4387	4387
Mean of dependent variable	1.510	0.009	0.036	0.034	0.076	0.034
Within-individual std. dev. of dep. var.	0.625	0.275	0.281	0.257	1.370	0.433

Notes: Table reports results from a cross-sectional OLS regression of the dependent variable shown in the column heading on wave fixed effects, Age, Age^2, Household size, and a dummy for whether the individual is single. In column (3), severe diabetes is defined as the sum of two dummy variables for whether the respondent takes insulin and whether the respondent has ever been hospitalized for kidney problems; in column (4), severe diabetes is defined if either dummy equals 1. In column (5), severe stroke is defined as the sum of 7 dummy variables for whether the respondent has vision problems, memory problems, speech problems, has seen a doctor recently, has general weakness from stroke, has therapy from stroke, or whether the respondent has other long-lasting problems from stroke; in column (6), severe stroke is defined if any of the 7 dummy variables equals 1. Standard errors, adjusted to allow for an arbitrary variance-covariance matrix for each individual over time, are in parentheses and p-values are in brackets.